THE BUILDING MATERIALS

OF

PENNSYLVANIA.

I.—BROWNSTONES,

BY

THOMAS C HOPKINS, M. S., M. A.,
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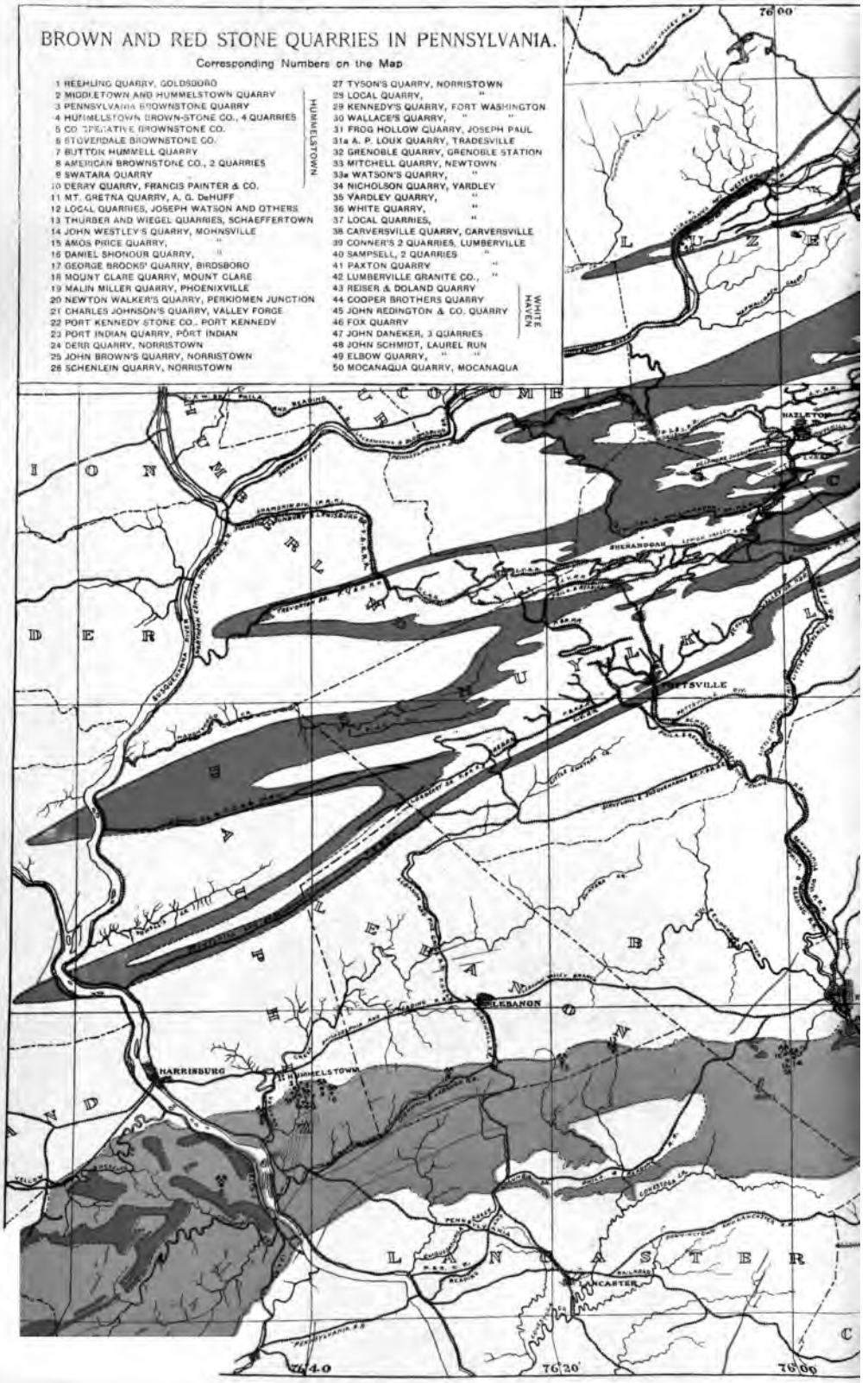
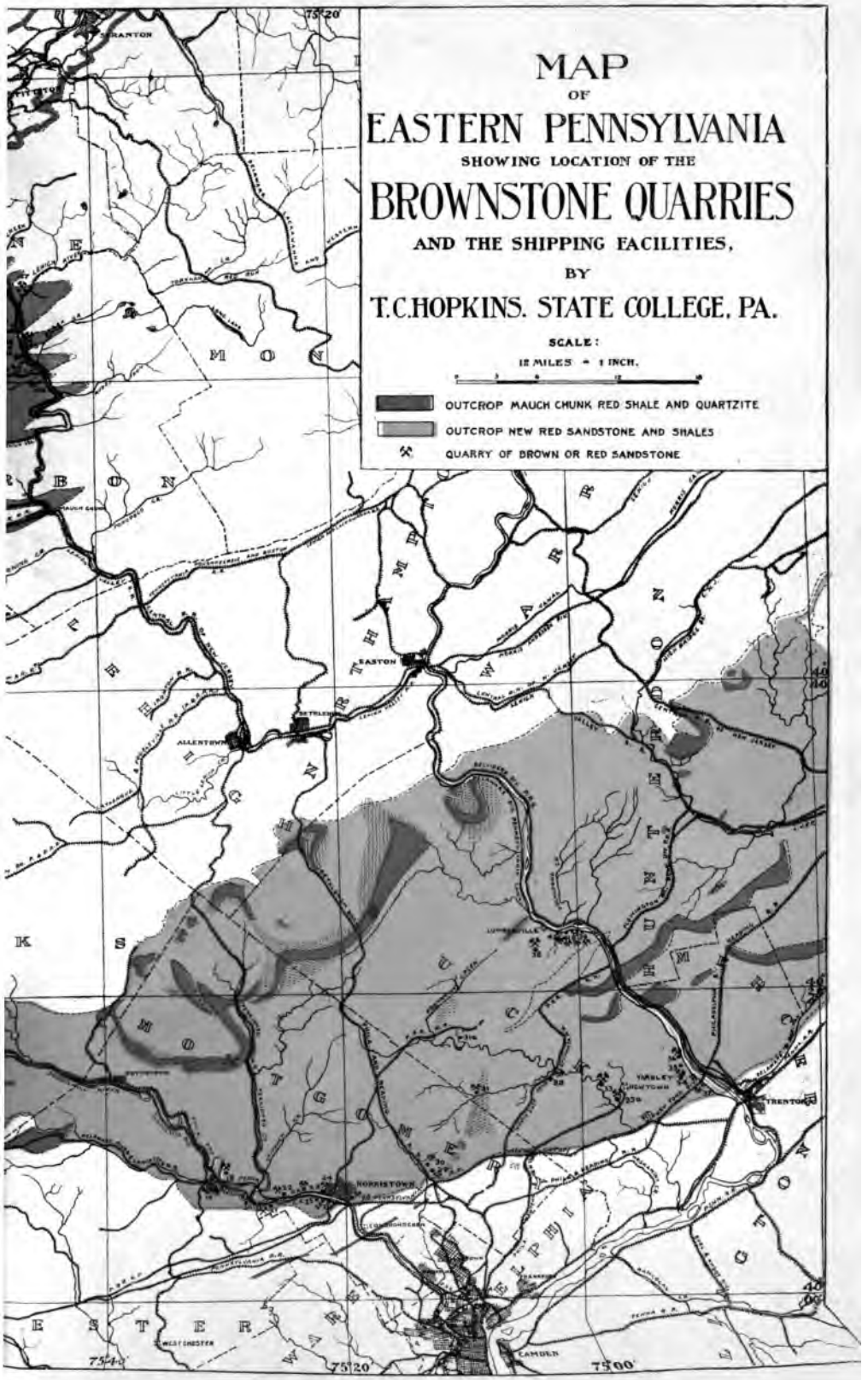
APPENDIX
TO THE ANNUAL REPORT
OF
PENNSYLVANIA STATE COLLEGE
FOR 1896.


BROWN AND RED STONE QUARRIES IN PENNSYLVANIA.
Corresponding Numbers on the Map
1 REEMLING QUARRY, GOLDSBORO
2 MIDDLETOWN AND HUMMELSTOWN QUARRY
3 PENNSYLVANIA BROWNSTONE QUARRY
4 HUMMELSTOWN BROWN-STONE CO., 4 QUARRIES
5 CO OPERATIVE BROWNSTONE CO.
6 STOVERDALE BROWNSTONE CO.
7 BUTTON HUMMELL QUARRY
8 AMERICAN BROWNSTONE CO., 2 QUARRIES
9 SWATARA QUARRY
10 DERRY QUARRY, FRANCIS PAINTER & CO.
11 MT. GRETNA QUARRY, A. G. DeHUFF
12 LOCAL QUARRIES, JOSEPH WATSON AND OTHERS
13 THURBER AND WIEGEL QUARRIES, SCHAEFFERTOWN
14 JOHN WESTLEY'S QUARRY, MOHNSVILLE
15 AMOS PRICE QUARRY, "
16 DANIEL SHONOUR QUARRY, "
17 GEORGE BROOKS' QUARRY, BIRDSBORO
18 MOUNT CLARE QUARRY, MOUNT CLARE
19 MALIN MILLER QUARRY, PHOENIXVILLE
20 NEWTON WALKER'S QUARRY, PERKIOMEN JUNCTION
21 CHARLES JOHNSON'S QUARRY, VALLEY FORGE
22 PORT KENNEDY STONE CO., PORT KENNEDY
23 PORT INDIAN QUARRY, PORT INDIAN
24 DERR QUARRY, NORRISTOWN
25 JOHN BROWN'S QUARRY, NORRISTOWN
26 SCHENLEIN QUARRY, NORRISTOWN
27 TYSON'S QUARRY, NORRISTOWN
28 LOCAL QUARRY, "
29 KENNEDY'S QUARRY, FORT WASHINGTON
30 WALLACE'S QUARRY, " "
31 FROG HOLLOW QUARRY, JOSEPH PAUL
31a A. P. LOUX QUARRY, TRADESVILLE
32 GRENOBLE QUARRY, GRENOBLE STATION
33 MITCHELL QUARRY, NEWTOWN
33a WATSON'S QUARRY, "
34 NICHOLSON QUARRY, YARDLEY
35 YARDLEY QUARRY, "
36 WHITE QUARRY, "
37 LOCAL QUARRIES, "
38 CARVERSVILLE QUARRY, CARVERSVILLE
39 CONNER'S 2 QUARRIES, LUMBERVILLE
40 SAMPSELL, 2 QUARRIES "
41 PAXTON QUARRY "
42 LUMBERVILLE GRANITE CO., "
43 REISER & DOLAND QUARRY
44 COOPER BROTHERS QUARRY
45 JOHN REDINGTON & CO. QUARRY
46 FOX QUARRY
47 JOHN DANEKER, 3 QUARRIES
48 JOHN SCHMIDT, LAUREL RUN
49 ELBOW QUARRY, " "
50 MOCANAQUA QUARRY, MOCANAQUA
HUMMELSTOWN
WHITE HAVEN
76°00'
76°40'
76°20'
76°00'
HARRISBURG
HUMMELSTOWN
LEBANON
LANCASTER
HAZLETON
SHENANDOAH
TAMAQUA
TRENTON
PHILADELPHIA


MAP
OF
EASTERN PENNSYLVANIA
SHOWING LOCATION OF THE
BROWNSTONE QUARRIES
AND THE SHIPPING FACILITIES,
BY
T.C.HOPKINS. STATE COLLEGE, PA.
SCALE:
12 MILES = 1 INCH.
OUTCROP MAUCH CHUNK RED SHALE AND QUARTZITE
OUTCROP NEW RED SANDSTONE AND SHALES
QUARRY OF BROWN OR RED SANDSTONE
SCRANTON
EASTON
ALLENTOWN
NORRISTOWN
TRENTON
CAMDEN
WEST CHESTER
75°20'
75°00'

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to Philadelphia is more than double that; thus $1,000 worth of stone costs $2,500 to transport it, so that we pay $3,500 in Pennsylvania for $1,000 worth of Indiana stone. Supposing it costs double the amount to quarry the stone in this State that it does to quarry it in Indiana there would still be a saving in using home stone to say nothing of the increased wealth to the State.

The other sandstones, the limestone, marble, serpentine, trap, and granite rocks are all susceptible of a more extended use than they have at present.

The demand at present is for a light colored stone and while I believe it not only possible but probable that there is sufficient stone of good quality of this kind in the State to supply at least the local demand, if not that of outside markets, it is not possible with the present knowledge to direct any one desiring such stone to a place where he can obtain it. Until that can be done stone will continue to be brought in large quantities from other states to meet the demand. Investigation in the State along these lines ought certainly be a most profitable investment.

I found quarrymen in New Jersey making inquiries about a light colored sandstone in Clearfield county, stating that it was one of their chief rivals in the eastern markets, yet we find no mention of this stone in any of the state reports.

The stone wealth of this State is greater than that of any other state in the Union, yet less has been done towards investigating and making known to the people the occurrence and quality of this great source of wealth, than in many of the others.

Any one seeking information concerning the quantity, variety, occurrence and value of the building stones of the State in either official or private publications will be surprised at the paucity of such information. The demand for such data led to the preparation of this report.

Permit me to thank you for your kindly interest and help in this work and to acknowledge the uniform kindness and courtesy of the stone dealers throughout the area traversed.

Respectfully submitted,

T. C. HOPKINS.

To the President, State College, Pa.,
January 16, 1897.

CONTENTS.

ILLUSTRATIONS.

BROWNSTONES OF PENNSYLVANIA.

By T. C. Hopkins.

PART I. THE GENERAL FEATURES OF BROWNSTONES.

Introductory.— Brownstones are among the oldest, best known and handsomest building stones used in this country. The brownstone fronts of New York and other eastern cities are found in the most fashionable parts of the cities and in great numbers. It is true that some years ago the use of brownstone was a fad, so much so that all the quarries running to their full capacity could not supply the demand. As a result its use was carried to excess, not only in the use of much inferior stone, but in the monotonous architecture resulting from long blocks of gloomy brownstone houses with no mingling of colors and little variety of form.

The extent to which brownstone was formerly used in New York is shown in the 10th census report, 1880, in which it is stated that of the stone buildings in New York city 78.6 per cent. consists of brownstone, which included 9,143 brownstone buildings in the city proper and 19,154 in the city and the suburbs, of which 79 were entirely of stone, the remainder with stone fronts. While the percentage in Philadelphia was not given, it would probably be much less. A writer in *Stone* less than two years ago (July, 1895), says that brownstone has not gone out of fashion, that as a matter of fact as much brownstone is being used in New York to-day as ever in the past, a statement which can hardly be substantiated, as a reaction has now set in, and the craze is for light stone. As a result we shall have in a few years monotonous blocks of light-colored limestone, marble and sandstone. By the time this second climax is passed, a more rational mode of procedure will prevail, architects and builders will begin to use stone that will harmonize with the plan and style of the building and with its location and surroundings. Then good building stone of different kinds and different colors will be in demand. Then the use of brownstone will again increase, as it is a useful and valuable building stone, one of the best if properly used and not abused.

Reliable information on the different brownstones is very scarce and widely scattered, so that one desirous of information in regard

to the quality and accessibility of the brownstones in different localities is at a loss to know where to turn. It is with the desire partially to fill this want that the present report is written, It is intended primarily for the Pennsylvania brownstones, but the chief commercial features of the brownstones from other states so far as could be obtained are given. Most of the ones mentioned come into competition with Pennsylvania brownstones in the markets both in this and in other states.

The aim has been in this report not to follow beaten paths, but to give such information and data concerning our brownstones, in as plain terms as possible, as would be of service to present and prospective quarrymen, to present and prospective buyers and dealers, and to the general reader. A state has not only a right but a duty to make known its own resources; that is, to make accessible to the reading public such data in regard to the occurrence, distribution and properties of its natural products as will lead to their more intelligent use.

Literature on Pennsylvania Brownstones.—Much has been written on the paleontology and some historical features of the eastern brownstones and published in the various journals and proceedings of scientific societies. These papers are all enumerated and classified in Bull. 85 of the U. S. Geol. Survey, The Newark System, by I. C. Russell, and only those few that have any bearing on the economics of the Pennsylvania brownstones are enumerated below. All of these are very brief, very general and, with one exception, local, There may possibly be a few other references to the occurrence of the brownstone in other reports of the Pennsylvania Geological cal Survey, but none that have any bearing on the economic side of the question. Merrill's work on Building Stones and the 10th Census Report referred to below describe briefly the building stones in all the states. Reference to articles on the brownstones of the different states are given under the name of the state where they are described in the text.

1. D'Invilliers, E. V.—Annual Report, Second Geological Survey of Pennsylvania, 1886, part iv. Paint, Iron Ore, Limestone and Serpentine, pp. 1563-1567. Brief description of the brownstone quarries in the vicinity of Hummelstown.

2. Frazer, Persifor.—Report of a Geological Survey of Chester County, Pennsylvania Geological Survey, CCCC, 1880, pp. 178-214.—The stratigraphic and paleontologic relations of the Mesozoic red sandstones in Chester County.

3. Frazer, Persifor, Jr.—The Geology of Lancaster County. Second Geological Survey of Pennsylvania, 1877, CCC, mentions the occurrence of the New Red sandstone in Lancaster County.

4. Lyman, Benj. Smith.—Report on the New Red of Bucks and Montgomery Counties, in Summary Final Report Geology of Pennsylvania, Vol. III, Part 2, pp. 2589-2638, 1895. Gives geological and topographical map of the New Red of Bucks and Montgomery Counties, with a detailed account of the stratigraphy, paleontology and general scientific features, and brief mention of the economic features.

5. Merrill, G. P.—Stones for Building and Decoration, Wiley & Sons, N. Y., 1891, pp. 279-281. Also in Smithsonian Report, Part 2, 1886.

Shaler, N. S.—Description of Quarries and Quarry Regions, 10th Census, Volume X, pp. 156-157. One of the best short descriptions of the brownstones of Pennsylvania.

Definition.—It might at first glance seem superfluous to offer a definition to such a simple term as brownstone, but the very fact that it is used with different meanings in the market is reason why it is advisable to state the significance of the word as used in this report.

If all the brownstones occurred in one locality and were all one shade of color, the term would be self-explanatory, but stone varying from gray, through all shades of yellow, red and brown, to black occurs in a dozen or more states, and in several different geologic horizons. The term brownstone in some localities is a synonym for the stone from Portland, Connecticut, because that is used in such large quantities, and no other is used at that point. With some persons brownstone signifies any rock from the Mesozoic or New Red formation, whether it be really brown or not. In this report the term is used for any stone that has a brown or red color, irrespective of locality or the geological formation in which it occurs. It also includes a light stone, which is not strictly brown except in places, but which occurs in the New Red formation, because it is so closely associated with brownstone, often in the same quarry, and because it commonly passes in the market as brownstone. Much of the Trenton brownstone in the market is not really brown, but gray, yet brownstone may come from an adjoining, often from the same, quarry. There is also included red or brown stone from the Paleozoic rocks, which may not be generally known in the market under the name brownstone, but which is as truly brown in color as many of the Mesozoic brownstones. Hence the term is here used to designate a sandstone with a brown or red color rather than a brownstone from any particular locality or formation. The red or brown marbles are not included.

Colors.—Brown is defined as a dark color shading towards red, yellow or black, and may be produced by a mixture of these colors.*

*Stardard Dictionary.

We can thus see that there may be an almost infinite number of shades of brown, grading insensibly into red, yellow or black, and that there may be wide divergence of opinion as to where the division should be made. In the sandstones the change is most frequently towards the red, less commonly to the yellow. So close is the relation that the same stone is called by some dealers red and by others brown.

The color is almost wholly due to the oxides of iron, the yellow and yellow-brown to the hydrous oxide and the red and red-brown to the anhydrous form. The shade of color depends partly on the hydration of the iron, partly on the fineness of the particles and the manner of their distribution. A small percentage of manganese affects the color in some localities, the tendency of the manganese oxides being to give a purplish tint.

From the standpoint of color, brownstone is one of the best of building stones, not only because of the wide range of shades to select from, but from the inherent beauty and richness of many of the shades, and what is of great importance in architecture, the permanency of the color. There is probably not another color common among building stones that is as permanent and as little liable to tarnish as brown. In some brownstone buildings that have been standing nearly 100 years the stone is as bright as when it first came from the quarry.

Where brownstone is used to excess, particularly dark shades, and along narrow streets, it is gloomy and sombre. It is used to best advantage in combination with other colored building stones, or at least with a more general use of lighter brownstones. The darker colored stones, while more sombre than the lighter shades, show the dirt and stains of the city atmosphere less and are in this respect better adapted to base-courses and trimmings. The inherent beauty and permanency in the color, together with its desirability in combination with stones of other colors for architectural effect, will always cause a demand for brownstone by the best architects.

The brownstones of Pennsylvania have as wide a range in color as those of any other state. There is the rich purple-brown and red-brown at Hummelstown, the dark brown at Mohnsville, the light, warm, red-brown at Cornwall, the light purplish brown at Newtown and Yardley, the very light brown to gray at Lumberville, Grenoble and Fort Washington, the light pink south of Birdsboro, and the light red and dark red at White Haven and Laurel Run.

The chemical composition of brownstones.—The accompanying table of analyses giving the chemical composition of all the well-known brownstones in this country so far as they could be obtained. The *first table gives* those of Pennsylvania, the second those from other *states for comparison*. It may be noticed in comparing these that

the Hummelstown stone corresponds more nearly with that of East Longmeadow, Massachusetts, than any other. The one analysis of the Hummelstown stone (No. 9) corresponds very closely with one from East Longmeadow (No. 14), the Worcester quarry "brownstone," but the other Massachusetts specimen (No. 15), from the Maynard quarry "red stone," is much lower in silica, higher in alumina and lime and much higher in alkali, indicating more feldspar, and possibly mica.

The stones of the eastern part of the State more nearly resemble the New England brownstones than those farther west in the State, but even they have a high percentage of silica, a lower percentage of alumina and a much lower percentage of alkali than the New England brownstones.

The signification of the varying proportions of the different substances is not always perfectly clear, but a number of very useful deductions can be made as follows: of all the substances mentioned silica is the most durable, especially if it occurs in the form of quartz. It is desirable to have the percentage of silica as high as is consistent with the desired hardness and workability of the stone. That is, from the standpoint of durability alone quartz is the most desirable substance, but if the silica is all in quartz grains and the percentage too high the stone will be friable, from not having sufficient cement to hold the grains together; on the other hand, if part

Analyses of Pennsylvania Brownstones.

No.	Location of Quarry.	Specific gravity.	Silica SiO_2.	Alumina Al_2O_3.	Ferric Oxide Fe_2O_3.	Ferrous Oxide FeO.	Lime CaO.	Magnesia MgO.	Manganic oxide Mn_2O_3.	Potash K_2O.	Soda Na_2O.	Water H_2O.	Total.
1	Hummelstown Brownstone Co.—blue.	2.657	90.34	4.35	1.60	.74	.35	.17	.....	1.30	.19	.61	99.74
2	Hummelstown Brownstone Co.—brown.	2.669	88.96	4.74	2.19	.....	.86	.44	.....	1.31	.24	.87	99.61
3	Swatara Brownstone Co.,	.....	91.52	3.80	2.02	.....	.50	.22	.....	(1)1.20	.....	.74	100.00
4	Mt. Gretna,	2.695	91.07	2.68	3.29	.....	.23	.33	.....	1.12	.24	.73	99.68
5	Westley's quarry, Mohnsville,	2.73	84.96	7.78	3.71	.....	.10	.38	.18	1.11	.43	1.40	100.05
6	Grenoble Station,	2.66	79.08	12.42	2.50	.....	.....	.....	.09	2.02	3.01	.55	99.67
7	Mitchell's quarry, Newtown,	2.66	82.34	11.46	1.07	.....	.27	.19	.07	.17	3.76	.80	100.13
8	Yardley quarry, Yardley,	2 675	82.72	10.29	1.92	.....	.17	.36	.16	.10	2.92	1.20	99.84
9	Hummelstown,	.....	88.13	5.81	1.77	.31	.20	.53	.....	2.63	.06	.49	99.93
10	Laurel Run red stone, Laurel Run,	2.656	(2)94.00	tr.	1.98	.....	1.10	1.00	tr.	.....	.....	(3)1.92	100.00
11	Daneker's quarry, White Haven,	.....	90.36	2.17	(4)1.15	.....	2.00	tr.	.....	.....	.....	.....	95.68

Analyses 1 to 8 inclusive made in Chemical Laboratory, State College, Pa. No. 9 by E. A. Schneider. Bull. 90 U. S. Geol. Surv., p. 65. No. 10 by A. A. Brenaman, N. Y. No. 11 Crane Iron Co's. Laboratory.

(1) Includes alkalies and loss.
(2) Silica and insoluble residue.
(3) Volatile matter—water and carbonic acid.
(4) Given as protoxide evidently a mistake.

Analyses of Brownstones.

No.	Locality.	Silica SiO_2.	Alumina Al_2O_3.	Iron oxide Fe_2O_3.	Lime CaO.	Magnesia MgO.	Alkalies K_2O, Na_2O.	Water.	Total.	Authority.
12	Portland, Ct.,	69.94	13.15	2.48	3.09	tr.	8.73	(1)1.01	.....	Merrill building and ornament stones, p. 420.
13	Cromwell, Ct.,	70.11	13.49	4.85	2.39	1.44	7.37	.....	100.00	N. E. Brownstone Co.
14	E. Longmeadow, Mass., "Worcester quarry,"	70.84	13.15	2.48	3.09	tr.	8.73	1.01	100.00	Worcester Polytechnic Institute.
15	E. Longmeadow, Mass., "Maynard quarry,"	88.89	5.95	1.79	.27	.....	.86	(1)1.83	100.00	Worcester Polytechnic Institute.
16	Wilburtha, N. J.,	79.38	8.75	2.43	2.57	.....	4.08	(1)2.79	100.00	Geol. of New Jersey, 1868, p. 515.
17	Wilburtha, N. J.,	93.55	4.00	.....	.40	.18	.30	.12	99.63	Geol. of New Jersey, 1868, p. 516.
18	Milford, N. J.,	93.60	1.59	3.30	.....	.....	.35	1.20	100.04	Geol. of New Jersey, 1868, p. 516.
19	Centre Bridge, N. J.,	79.25	7.49	3.78	1.86	.....	1.12	3.16	(3)99.51	Geol. of New Jersey, 1868, p. 515.
20	Washington Valley, N. J.,	96.20	1.58	(2)1.37	.15	.36	.....	1.15	98.59	Geol. of New Jersey, 1868, p. 515.
21	Hancock, Maryland,	88.45	3.92	3.03	.36	.12	.88	1.80	98.70	Bulletin 55 U. S. G. S., page 80.
22	Hancock, Maryland,	76.43	17.78	.....	.84	.92	.....	.....	98.76	Bulletin 55 U. S. G. S., page 80.
23	Sanford, N. C., brown,	(4)88.68	.....	7.13	1.32	.....	.....	2.20	.....	Garrett & Dix, Philadelphia.
24	Sanford, N. C., red,	81.59	10.81	4.38	1.02	.33	1.08	.79	100.00	Garrett & Dix, Philadelphia.
25	Mansfield, Ind.,	82.58	8.95	3.95	1.18	.81	.83	1.68	100.00	Rose Polytechnic Institute.
26	St. Anthony, Ind.,	(5)92.16	.....	6.29	.05	.....	.09	.....	98.59	Rose Polytechnic Institute.
27	Bloomfield, Ind.,	(5)88.41	.63	8.40	.13	.....	.....	.....	97.57	Rose Polytechnic Institute.
28	Greenhill, Ind.,	(5)85.29	.19	11.83	.06	.....	.....	.....	97.43	Rose Polytechnic Institute.
29	Hillsboro, Ind.,	98.73	.28	.36	.03	.....	.....	.....	99.40	Rose Polytechnic Institute.
30	L'Anse, Mich.,	(5)91.65	.56	6.60	.12	.....	.....	.....	98.93	Rose Polytechnic Institute.
31	Portage Entry, Mich.,	78.55	14.21	5.54	.42	tr.	.....	.....	.....	
32	Portage Entry, Mich.,	90.17	4.23	3.16	.....	.29	.....	1.01	100.00	Mariner & Hoskins, Chicago.
33	Marquette, Mich.,	82.60	8.32	.28	.55	.18	6.49	.99	99.90	Report Geol. Surv. Mich., 1891-2.
34	Keweenaw Bay, Mich.,	77.18	9.69	3.20	0.26	1.48	4.85	2.90	(6)100.00	F. F. Sharpless.
35	Houghton, Wis.,	78.55	14.21	5.54	.42	tr.	.....	1.28	100.00	Stone, Vol. IX, No. 1.
36	Bass Island, Wis.,	91.40	3.53	2.00	.25	.....	2.50	.05	99.73	Columbia College School of Mines.
37	Fond du Lac., Minn.,	87.02	7.17	3.91	.11	.06	1.66	.....	99.92	Geol. of Wis., Vol. III, page 208.
38	Flagstaff, Ariz.,	78.24	10.88	3.83	.95	1.60	1.72	.....	97.23	Geol. of Minn., Vol. I, page 202.
39	Kettle River, Minn.,	79.15	1.30	2.45	7.76	.23	.....	3.26	(7)99.96	Bull. 78, U. S. G. S., p. 124.
40	Pipestone, Minn.,	98.69	1.06	tr.	.42	.01	.17	.....	.....	N. H. Winchell.
		84.52	12 33	2.12	.31	tr.	.45	(1)2.31	.....	

(1) Includes water, CO_2, and loss. No. 14 contains 0.41 per cent. manganese dioxide.
(2) Iron given as protoxide.
(3) Includes also sulphuric acid 1.39 per cent. and carbonic acid 1.46 per cent.
(4) Insoluble residue. No. 21 is analysis of the same as 22, in which all the silica is determined by fusion with soda carbonate. Both from the Jaltelle quarry.
(5) Insoluble residue includes silica and insoluble silicates.
(6) Includes P_2O_5 0.21 per cent. and SO_3 0.23.
(7) Includes 5.77 CO_2 analyzed by T. M. Chatard.

of the silica is in the form of cement binding the grains together, the stone is liable to be too hard to work. Hence, no definite limit can be placed on the amount of silica allowable in a good stone, as that depends on whether a hard stone or easy-working stone is desired, and also on how much of the silica is in feldspar, mica or clay,—the proportions of alkali, lime and alumina throw much light on this point. It also depends on the size and shape of the grains; thus round grains require more and stronger cement than sharply angular grains to produce a stone equal in strength; irregular angular grains when closely compact will make a very strong stone with very little cement, because of the interlocking of the grains among themselves.

A high percentage of alumina is not desirable; if in the form of feldspar or mica it is a source of decay; if in the form of clay it will absorb water and injure the stone by freezing. The last injury is intensified if the clay is segregated in patches or layers. On the other hand, a certain percentage of clay is desirable to make an easy-working stone. If the cement is entirely or largely quartz or calcite the stone will be too hard to work freely. No arbitrary standard can be given for the maximum percentage of alumina allowable, as that depends on the form in which it occurs, the manner of its distribution, the shape of the grains and the desired use of the stone.

The iron oxide is desirable within reasonable limits, providing it occurs in the peroxide form, as it gives the color to the stone and forms a strong and durable cement. It generally occurs associated with more or less clay. If the iron occurs in the form of pyrite or carbonate it is liable to be a source of disintegration. It is customary in making the analysis to determine the iron as peroxide without proving it to be such. Hence the small percentage of protoxide given with the Hummelstown stone does not signify that it does not occur in any of the others, but simply that it was not determined in any of the others, and that it does not occur in sufficient quantities in the Hummelstown stone to be any serious injury to the stone, as might be suggested by its blue color.

The lime is not a desirable element. It is probably less injurious in the form of feldspar (the form in which much of it occurs in the analyses given) than in the form of calcite, as in the latter case it hardens the stone; where it does not form all the cement it hardens it unequally, and is, furthermore, more soluble than the other substances, and is in that way a source of weakness. In the first instance the only injury is in the presence of the feldspar, which is liable to decay.

The alkalies are not desirable substances on account of their solubility. *In the fresh* feldspar they are insoluble, but in most of the *sandstone the feldspars* are more or less decayed, and as they decay

the alkalies go in solution and frequently act on the other substances. The white efflorescence sometimes seen on the face of the sandstone outcrops is due (in many cases, at least) to the alkali salts from the decaying feldspars.

Mineralogical composition of brownstone.—The mineralogical composition is frequently as valuable an indication of the quality of the stone as the chemical composition, and sometimes more so, especially when combined with a microscopic examination, which shows not only the minerals present, but the relative quantity and the condition in which they occur. The bulk of all sandstones is made up of quartz grains, which generally form from 70 to 95 per cent of the rock. In the quartzites the grains are cemented by quartz deposited in the interstices, thus giving a high percentage of silica. However, a high percentage of silica does not always signify a quartzite, as may be seen on comparing a few analyses in the foregoing tables. Thus, the Mt. Gretna and the Hockersville stone each show a percentage of more than 91 per cent silica, while the White Haven stone has less than 91 per cent, yet the first two, especially the Mt. Gretna stone, are friable sandstones, and the last a hard quartzite. Likewise the Wilburtha stone, which has 93 per cent. silica, is a soft stone, and the Mansfield, Indiana, stone, with more than 92 per cent. silica is a friable sandstone, and the Lumberville stone, which is a hard quartzite, has less than 80 per cent. silica. The advantage of the microscopic examination over the chemical or rather in combination with the chemical, is that it shows the form in which these elements occur. Thus, the Lumberville stone has the grains of quartz and feldspar firmly bound in a quartz cement, which would not be shown by the analysis.

The next most abundant substance after quartz found in the grains of sandstone is feldspar. In some localities orthoclase and microcline, the alkali feldspar, are abundant, while in other places plagioclase, or basic feldspar, predominates As most of the feldspars occur in sandstone in a more or less decayed condition, where plagioclase abounds, calcite is liable to be found in the sandstone, and in many places there is an efflorescence, formed on the stone in protected places, of sodium or potassium sulphate from the alkali of the feldspar. While this efflorescence was observed in many places it was only analyzed from one locality (Port Kennedy), and there it proved to be mirabalite, or glauber salt (sodium sulphate). The resulting products of decaying feldspar are numerous, depending on the conditions under which it decomposes. The most common products are clay, quartz and muscovite (mica). In none of the brownstones examined was muscovite observed in large flakes where it appeared to be a secondary product, but aggregates of clay with much finely granular quartz and minute portions of some highly polarizing mineral that is probably muscovite, are plentiful, some-

times in a rim of feldspar, sometimes with included fragments of partially decayed feldspar; in fact, nearly all stages from fresh looking feldspar to clay in which the outlines of the feldspar have been lost.

Mica which is quite abundant in the New England brownstone is very scarce in the Pennsylvania brownstones, occurring only in a few widely scattered fragments. It readily decomposes, and is an element of weakness, not alone from its disintegration, but likewise from the tendency of the flakes to all lie the same way and make planes of easy cleavage, along which the stone flakes and scales on exposure. The scaling is much worse where the mica is much decayed. It is one of the most injurious minerals that occur in sandstones.

Iron oxide in the form of hematite and limonite occurs diffused through the clay cement, and surrounding many of the grains of sand. It occurs in such a finely divided state that it is impossible in some cases to determine what mineral form it takes. Most of it is presumably red hematite judging from the color of the rock, and in some place small hematite crystals are distinguishable.

Calcite occurs in small quantities in the interstices between the grains in some localities, but in general the percentage is very small. It is most abundant in the hard stone from White Haven and Laurel Run.

Other minerals occur in small quantities, but not in sufficient abundance to affect the durability or character of the stone to any extent. Small crystals of apatite, zirkon and rutile occur in the quartz grains, and small fragments of magnetite, augite, and hornblende were observed. There are likely to be present small fragments of any minerals that occur in the rocks from which the debris was obtained. The contents of the different varieties are given under the headings where they are described.

Structural features of brownstone.—Brownstones vary in structure from fissile shales on one side to massive seamless beds on the other. The thin-bedded stone that occurs in regular layers less than five or six inches thick, if sufficiently hard, is used for flagstone; in irregular layers it has no value except for broken stone or for cellar walls. In many instances quarries that furnish flagstone at the outcrop furnish heavy dimension stone in the interior, the numerous bedding planes being opened by the weathering influence. This is particularly true in the White Haven and the Laurel Run red stone quarries.

As in other sandstones, false bedding or cross-grain is common in the brownstones. Sometimes the flagstone layers are formed by the false-bedding planes. (See fig. 1 and plate 26.) The false bedding is

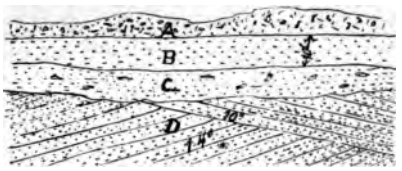


Fig. 1. Section on the face of one of the Laurel Run quarries, showing false bedding or cross-grain. A—Glacial material. B—Heavy bed red sandstone. C—Sandstone with small cavities. D—Cross-bedded red sandstone.

in nearly all cases an injury to the rock causing a great deal of waste, and making the stone difficult to quarry and dress properly. False-bedded stone is nearly always banded and varied in texture, having alternating streaks and patches of fine and coarse grained stone.

If the stone is soft enough to be easily channeled, a massive form entirely free from seams, either bedding seams or wall seams, is the most desirable. If the stone is so hard as to be channeled with difficulty, a certain number of bedding planes or seams is desirable for the economic production of the stone. The lack of sufficient bedding seams is often balanced by the number of joint or wall seams, which are liable to be very abundant if the rock is hard and has been subjected to much folding or pressing. The joint seams are important features in the Lumberville quarries. (See plates 22 and 23.) In some places the joint seams become so abundant as to cause much waste in the rock, and in some instances cut it up into such small dimensions as to ruin it entirely for building stone. The bedding planes are frequently irregular, not even or parallel with each other, thus causing much waste when squaring the blocks; where these irregular seams come close together fine dimension stone cannot be obtained, and the stone can only be used for rough work.

Textural and microscopic features of brownstones.—Like all other sandstones, the brownstones vary in texture, grading from the shales and slates on the one side to the coarse conglomerate or pudding stone on the other, thus forming an intermediate class between these two. The coarse-grained varieties look well in heavy masonry in rock face work, and are better adapted to that line of work, the finer grained being better adapted to fine carving or tool dressed surface, but adapted to rock face work as well. The most desirable texture from a commercial standpoint is one that is homogeneous throughout and not very coarse, but a uniformly coarse-grained stone is better than one having a mixture of fine and coarse grain. As a rule the coarse-grained rocks are more porous and absorb water more freely, and hence are more liable to injury from

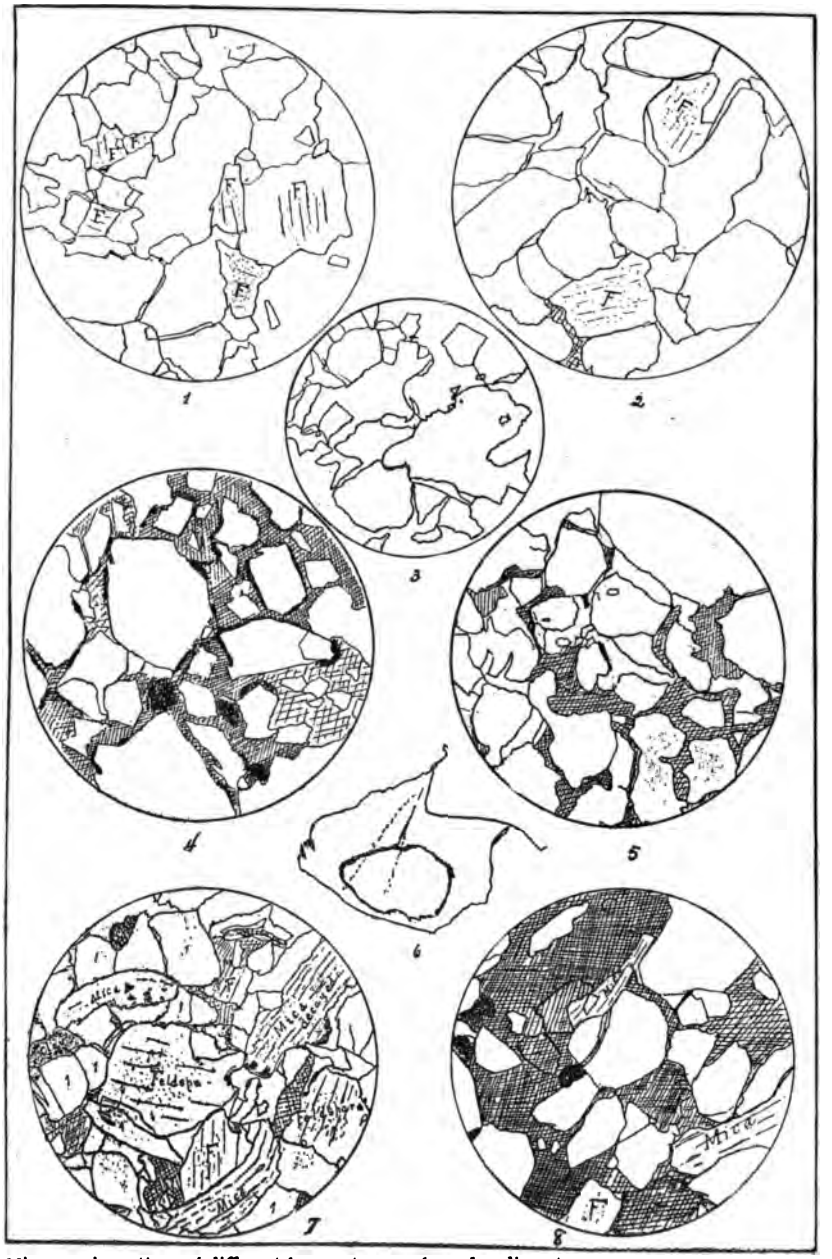
frost. On the other hand, they are less liable to be laminated or reedy, less liable to have clay seams, and will generally work more freely in all directions and are also less liable to be cut up by numerous seams, both vertical and horizontal, than the fine-grained ones. The fine-grained stones are generally stronger, but less elastic, not so apt to disintegrate, but more apt to crack or shell. They are equally well adapted to rock-faced, tool-dressed, or fine carved work.

The coarse conglomerate is abundant in several places over the brownstone area, but so far as observed by the writer, none of it in which the pebbles are the size of hickory nuts or larger has any value for building stone, as the cement is not strong enough to hold the hard pebbles in place. A conglomerate from this formation is quarried at the Point of Rocks, Maryland, in which the large pebbles are limestone, and it is known in the market as Potomac or calico marble. A stone somewhat similar in character to the Potomac marble is said to have been quarried at one time in Lancaster county, Pa., but the pebbles would drop out of the mass, and its use was abandoned. The upper part of plate 18 shows a view of one of the coarsest conglomerates in the State.

The microscope reveals several features in regard to the texture and composition of the rocks that are not brought out in any other way. It reveals both the mineral constituents and their condition of preservation, the proportions, kind and character of the cement. Some of these features are illustrated on the accompanying drawings* of typical sections of several varieties of rocks (Plate 1). Numbers 1 and 2 it will be noticed resemble each other somewhat and are strikingly different from the others. They each represent a very hard quartzitic sandstone with considerable feldspar among the grains, particularly No. 1, and having very little clay cement, nearly all the cement being crystalline quartz deposited in the interstices locking the grains into a very firm mass. The grains are all white, gray or colorless. No. 2 however in the rock mass is red or red-brown, which is produced by an exceedingly thin pellicle of red iron oxide partially surrounding many of the grains and small segregations in some of the more decayed feldspar and clay particles not shown on the drawing. It must be kept in mind that each of the drawings represents an area of the rock not much larger that the head of a pin, that is one forty-fourth of the diameter of the figure. No. 3 is an enlarged view of a more fine-grained portion of No. 2, which is entirely quartz, the secondary quartz binding the original grains in a mass. Nos. 4 and 5 are fairly representative samples of the Hummelstown stone (See also plate 10) composed of angular and subangular quartz in a cement of clay and

*Drawn with camera lucida enlarged 88 diameters and reduced one half.

Brownstones of Pennsylvania. Plate I.



Microscopic sections of different brownstones enlarged 44 diameters:

No. 1—Lumberville feldspathic sandstone—feldspar and quartz and quartz cement.

2—White Haven red stone, some feldspar, mostly quartz and quartz cement.

3—An enlarged granule from No. 2 showing its quartzitic character in spots.

4 and 5—Typical sections of the Hummelstown brownstone.

6—Enlarged view of single grain of the Hummelstown stone showing secondary quartzose character.

7 and 8—Sections of a well known New England sandstone showing its micaceous character.

F signifies feldspar; cross-lined areas aggregates of clay, fine quartz, and iron oxide; very *dark shading* iron oxide; colorless areas quartz.

iron oxide. No. 5 is an area above the average in the relative proportion of quartz to the mass. No. 4 shows about the average percentage of quartz but the grains are more angular than the average; in some of the grains parts of the crystal faces may be seen. The freestone character of the rock is brought out fairly well, showing its adaptability to carving. It will be noticed that there is no parallelism about the grains and a line of fracture would run equally well in any direction. No. 6 is an enlarged view of a single grain from another portion of No. 5 showing its quartzitic character or origin. The original grain is shown near the middle of the figure, surrounded by the quartz subsequently deposited. All this took place before it became part of the Hummelstown stone, and the inner grain has been part of no less than three rocks of different ages, and the entire grain has formed part of at least two.

Nos. 7 and 8 are of a well known New England brownstone and given by way of contrast; No. 7 is a little above the average in the percentage of mica in the sample, and No. 8 a little above the average in the proportion of cement. Here one may read one of the causes of the scaling fronts of our eastern cities. Mica flakes or scales easily enough when fresh, but much more so when partially disintegrated and the fact that so many flakes lie in parallel directions is a great source of failure in the rock. Very little mica was observed in any of the Pennsylvania quarries.

The microscopic features of the different varieties are given elsewhere in this report with the description of the stone to which they refer.

Varieties of Pennsylvania Brownstones:—There is probably a greater variety of brownstone in the State of Pennsylvania than in any other state in the Union. Only the general properties of the more common types are mentioned here and the different varieties are described more in detail in subsequent chapters.

In the New Red formation there are many varieties, the best known being the red-brown and the purple-brown Hummelstown stone, a fine grained stone, homogeneous in color and texture. The red-brown is a brighter color than the more eastern stone and the purple a richer color, both varieties being possibly a little harder than the eastern stone. They are said to work easily and are quite durable, standing the northern climate remarkably well and standing abrasion in steps or walks better than the average brownstone. It contains proportionately more quartz and less feldspar and mica than much of the eastern stone; in fact it is almost free from mica, the most injurious of the minerals.

The Cornwall, Mt. Gretna, and Schaefferstown stone is in general coarse-grained, contains many pebbles, has a light, warm, rich red

color varying from the light to a deep red in different localities. It has been obtained in limited quantities free from pebbles and makes a very handsome stone.

The Mohnsville stone is dark-colored, as dark as the eastern brownstone and contains many pebbles. It is associated with large beds of conglomerate. There are three varieties at Birdsboro and vicinity: a red shale, red-brown pebbly stone, and a light pink stone.

The Valley Forge, Port Kennedy stone is dark colored, coarse grained, and pebbly. At Norristown there is both gray and light brown stone irregularly bedded, mostly in small irregular pieces. The Fort Washington, Grenoble stone is light brown to gray and soft like the Norristown stone, containing many irregular seams, a nice building stone but not obtainable in large dimensions. The Frog Hollow stone is dark colored and hard, a strong durable stone regularly bedded. Newtown and Yardley stones are light brown colored with a faint purple tint and soft, occurring in regular beds with seams regular and even, furnishing dimension stone of good quality and pleasing color. The Lumberville stone is very hard, mostly light gray, but mixed gray and brown. The red stone of the Mauch Chunk formation at White Haven, Laurel Run, and Mocanaqua is very hard and generally uniform in color and texture. It, like the Lumberville stone, is intermediate in character between sandstone and quartzite. The "Brown granite" from Rockwood, Somerset county, resembles the White Haven stone. There is likewise a brownstone quarried at Ellwood City of which we have no data. There are both red and brown sandstones in the Medina, Clinton, and Catskill formations in different parts of the State, that so far as known have not been used for building and lack of time prevented a personal examination of the areas.

Durability of Pennsylvania Brownstones.—Much criticism has been raised in regard to the durability of the brownstones particularly in the cities. In New York and Philadelphia abundant evidence of its decay may be found in many of the brownstone fronts, conspicuously so in the ground courses and in small railings and columns of the steps and porches, yet in many places the plain surface of the walls is crumbling and scaling in a lamentable manner particularly along the base-courses. It is said to be customary with some residents in New York to have the faces of their brownstone fronts rubbed with stiff wire brushes every four years, to remove the disintegrated material and keep the wall clean, and sometimes where the stone is much decayed the stone-cutter cuts away the loose material, thus giving the stone a fresh appearance without removing it from the wall, and in some instances it has been found necessary to replace the stone by a new one. I am informed that the replacing of disintegrating stones in the wall by new ones

is a much more common practice in England than in this country, as the rocks seem to crumble more rapidly in that country.

The brownstone quarrymen claim that this disintegration of the rock is due to the fact that the stone has been wrongly laid in the wall, the claim being that the disintegrating stones are set on the edge and that if they had been laid on their natural bed they would have remained firm. This, however, is only one of a number of causes for the crumbling of the stone. While it may be and very probably is one of the most important factors in many cases there are other causes not to be ignored. They may all be enumerated as follows:

Causes of decay in the brownstones in the cities.

1. Setting the stone on edge. It should always be placed on its natural bed.

2. Quarrying in freezing weather or so late in the season that it could not be thoroughly dried (seasoned) before freezing.

3. Subjecting the stone to heavy blasting or to the blows of a heavy hammer in quarrying and dressing.

4. Carelessness in selecting the stone.

Where these precautions have been observed in selecting, working and using the stone (sometimes it is true accidentally, sometimes by intent,) it has been found to stand the test of time with a high degree of satisfaction. Tombstones in the cemetery at Middletown and Portland, Conn., have been standing there for two hundred years or more without a flaw. The same is true of some in the Trinity Church yard in New York city, and in the vicinity of Hummelstown, Pa., are stones more than 100 years old. The same is apparently true of the buildings since many of them as sound as when first erected, appear to be as old as others near by that are very much disfigured. These facts plainly show that the cause of decay is not necessarily inherent in the stone itself but due at least in large measure to mistakes in selecting and handling the stone. So important is this that it may be well to enlarge on some of the abuses above mentioned showing how they affect the life of the stone.

1. Setting the stone on edge — Nearly if not all sedimentary rocks have a grain and cleavage, most frequently seams of more or less prominence, commonly known as the bed or bedding of the rock. These were practically horizontal in the material as originally deposited or parallel with the surface of the water in which the material is deposited, except where the stone is cross-bedded, but where the rocks have been crushed, folded, or disturbed, the original horizontal position of the bedding may be changed to almost any angle with the horizontal, *yet the occurrence* of the seams or the grain or "reed" of the rock in *most instances shows* to the quarrymen the original bed of the rock.

The particles composing the rock as they are deposited in the water are mostly dropped on the flat or long side, overlapping each other in a rough way and being rudely bound together in every direction but the vertical one. Pressure from overlying material tends to intensify this character. As the rate of deposition is not uniform for a great length of time there will be changes in the texture between the different layers of deposit which are frequently differently indurated. A period of slow or no deposition permits a hardening of the surface causing a parting between the indurated material below and the sediment next deposited. The prominence of this lamination, commonly known as bedding, depends on the character and on the induration of this material, sometimes being an open bedding plane and sometimes incipient, showing only after long exposure to the weather. As the rate of deposition is never constant there is an indefinite number of these planes, some showing in the fresh rock, some after short exposure and some only after long years of exposure to the weather. There is probably no stratified rock that is wholly free from these partings, many that appear to be massive and free from these seams when fresh showing the seams often in great numbers after exposure in the wall. These horizontal seams besides being lines of weakness are water lines, the water permeating in this direction much more readily than across these planes, and when the stone is put in the wall on edge the water collects along the lamination planes and freezes, the ice crystals acting as wedges to split off the flakes of stone. If the stone were laid on its natural bed the water would not so readily penetrate the rock and if it should, the pressure from the overlying rock in the wall would prevent scaling, and even though flakes were loosened they would be imprisoned so that they could not escape if good mortar were used.

The fact that the stone does yield or split so readily in this direction is the principal reason that so much of it is set on edge as it can be faced so much more quickly and easily, as many of the brownstone fronts consist simply of a thin veneering of brownstone backed up with brick or frame work. The temptation to set the stone on edge is greater in this case than where it is used in heavy masonry. Most of the stone-cutters know full well the greater strength and durability of the stone on its natural bed and they also know how much more readily and cheaply they can split off the slabs and set them on edge in the wall than they can dress the faces across the edge. Hence, it is the element of cheapness that causes this abuse of the brownstone. This evil is more pronounced where the stone is dressed by hand. Where it is cut and dressed by machinery it is more likely to be properly placed as it can be

sawed or planed about as readily on the edge as on the bed and the dealer will put the stone the way his conscience tells him is the right way for the future reputation of the stone. It is customary in some places, and should be in all places, to specify in the contract that the stone is to be cut to lie on its natural bed.

2.—Every rock when first quarried contains a certain percentage of water known as the quarry water or sap that when once dried out is not re-absorbed. The quantity of this varies in different rocks, but as a general rule the more porous the rock the greater quantity of this water. Sandstones being the more porous of building stones have as a rule a larger percentage of sap than any other class of building stones. If the freshly quarried rock is exposed to freezing temperature before drying the freezing of the water will injure the rock, sometimes by bursting off small scales or flakes, sometimes even bursting the rock into several pieces; frequently the injury is not perceptible at once, as the minute cracks formed may not show for some time but greatly weaken the stone so that it will succumb to subsequent frosts or strains more readily. Some sandstone companies will not guarantee any stone that is quarried after November first, yet in the great hurry to fill contracts builders take the risk and rush the stone into the building at all seasons of the year. This was conspicuously the case a few years ago when brownstone was the craze and the quarries were overcrowded with orders, and there is without doubt a considerable percentage of the disintegration of the brownstone in our northern cities due to this cause.

The stone is all the better for being quarried at least one or two seasons before it is put in the wall and should be quarried early in the season so that it can be thoroughly dried before winter. It is customary now for many of the larger dealers, and should be with all to keep sufficient stock on hand to fill winter orders without quarrying fresh stone.

3.—More stone is injured by blasting and hammering than is ordinarily acknowledged by the quarrymen. Before the days of the stone channeler and the Knox blasting system the injury was much greater than at present, and no doubt much of that in the old brownstone buildings of New York and Philadelphia was quarried with the free use of powder. Where a heavy charge of powder is used to loosen a large quantity of the stone at one time the heavy jar shatters the stone causing many incipient cracks which frequently appear only after long exposure to the weather.

It was formerly customary in the Portland, Conn., quarries to put in very heavy blasts, by drilling holes 6 or 8 inches in diameter and putting in 2 or 3 kegs of powder, which would loosen, and at the same time shatter a great deal of the stone. While this process has *not been followed* for ten or twelve years in those quarries, much

1. Pennsylvania Railroad bridge at Middletown, Pa., of Hummelstown brownstone.

2. Bridge at Edison, Pa., built in 1800 of stone from the neighboring hills.

SHOWING DURABILITY OF PENNSYLVANIA BROWNSTONES IN BRIDGES.

of the stone now in use was quarried in this manner. I have heard quarrymen in this State speak boastingly of the large amount of stone they knocked loose with one blast, apparently not realizing the effect it would have on the stone.

The Knox system of blasting, by using light charges properly distributed is a great improvement over the old system and reduces the injury done to the stone but does not do away with it. A better method yet is to use the channeling machine but as it is a little more expensive the blasting will no doubt continue. Another injury done to the rock is breaking it with heavy hammers. A workman strikes repeatedly with a heavy hammer in one place or along a certain line sometimes for five or ten minutes, finally breaking the rock, but before doing so shattering it throughout, loosening the grains and cracking the cement, injuring the "life" of the stone. These minute fractures, like the powder cracks, are not noticed at the time, as the fresh stone as it goes into the wall seems perfectly sound but after exposure to the weather for a few years they begin to appear and the stone quickly cracks and crumbles to an alarming extent. This method of quarrying is all right for broken stone for macadam or lime burning, but it cannot be too strongly condemned for quarrying building stone.

4.—There is one other precaution too frequently overlooked and that is to throw out all the bad and inferior stone. There is some stone in all quarries, in some quarries a great deal of it, that is intrinsically bad containing streaks of shale or spots of clay or iron oxide, or an excess of mica, much of which it is true is rejected in the best quarries; yet frequently in the small quarries and occasionally in the large ones under stress of rapid shipment or to fill on order taken at a low bid imperfect stone is put in against the better judgment of the quarrymen.

While many of the brownstones are not ideal building stones from the standpoint of durability, if the stone is properly dressed and quarried, quarried at the proper season and carefully selected it will give as good satisfaction as probably almost any other stone in the market. It will be found on investigation that the scaling and the disintegration of the stone is due largely to one or more of the abuses above mentioned, all of which may be avoided with proper care. What has been said has special reference to the more eastern brownstones as they have been longer in use and more extensively used, hence are better known and more criticised, but it is applicable to all others as well.

Dr. Julien gives as the result of his extended observations on the building stones in New York City and suburbs the following as the life of brownstones: Coarse brownstone, 5-15 years. Laminated fine brownstone, 20-50 years. Compact fine brownstone, 100-200 years.

In another place he says in regard to brownstone that it seems to be a common, if not universal opinion (in his own opinion too hasty), that the days of the brownstone fronts for the better class of houses are probably numbered. It is the widely quoted opinion of one architect that it is of no more use for architectural work than so much ginger-bread; that the majority of the brownstone fronts will in 60 or 80 years be in ruins and the remainder much dilapidated.

That this was not and is not the universal opinion is shown by the continued use of brownstone. And it must still be borne in mind that there are good, bad and indifferent brownstones used with varying degrees of intelligence and lack of intelligence.

The qualities affecting the durability of the different brownstones of the State are discussed under the different varieties, as they vary widely in composition and texture, hence in the elements of durability.

Physical Tests.

Specific gravity.—By the specific gravity of the stone we mean its relative weight compared with water. Since all are comparable with water they are comparable with each other. The results in as far as they are accurate and intelligible show both the density and actual weight of the stone and give a means of comparing the different stones. However, as the result obtained depends largely on the method employed one is liable to grave errors in making comparisons if he does not know the method used in each case and the care used in making the test. For that reason we give the particulars in regard to the methods used in the following tables:

1.—The method used at State College was the specific gravity bottle, in which a small bottle, (.5 c. c.), is weighed (1), then filled with distilled water and weighed again (2). The bottle is then emptied, dried, the powdered stone put in and reweighed (3). These weights give the weight of the stone and the weight of the bottle full of water. The bottle containing the sample is partly filled with water and suction applied to exhaust the air bubbles and the filling completed and another weight taken (4). The specific gravity is then computed from the formula $\frac{3-1}{(2-1)-(4-3)}$. That is, the weight of the stone divided by the weight of the water displaced by the stone.

2.—General Gillmore's method* is to weigh the specimen in air, (A) then immerse it in water until bubbling ceases, and weighing (B) then removing it from the water and drying the surface in blotting paper and weighing again (C). The specific gravity is then found by dividing the weight of the dry stone by the weight of the saturated stone in air less its weight in water, the formula being $\frac{A}{C-B}$. specific gravity.

*Appendix II. Annual Report of Chief of Engineers for 1875. page 7.

3.—The method employed at the Rose Polytechic Institute, which is quite a common method for ordinary purposes, is to weigh the stone first in air, (A) and then in water as quickly as possible, (B) the specific gravity being the weight in air divided by the difference between the weight in air and the weight in water, $\frac{A}{A-B}$.

4.—The tests at Cornell University were made by weighing in air and in water and dividing by the loss of weight in water. But no particulars are given as to length of time the specimen was left in the water or the size of the pieces. Some were made by the Jolly balance and some by a chemical balance. The result is an average of 24 samples which vary between 2.586 and 2.722, a difference of nearly 9 pounds on the cubic foot.

The different processes enumerated will give different results. The first two aim to give the specific gravity of the particles or constituents of the stone exclusive of the air inclosed in the pores. They can only approximate that result as all the included air cannot be expelled. The third process aims to give the actual weight of the stone as it goes into the wall including the air in the pores. This can only approximate such a result as it is impossible to prevent the absorption of some water in the pores, the amount varying with the skill and speed of the operator. Hence the results, within the degree of accuracy attained, lie between the two extremes of the weight of the particles of stone exclusive of the air contained and the stone with all the included air.

A few comparative tests were made at State College to find the ratio between the results obtained by their method and those obtained by other methods, two on the Connecticut stones and one on the Laurel Run red stone. It will be noticed that there is a marked difference in the Connecticut stone and but little in the Laurel Run red stone, which may be accounted for by the fact that the latter is a dense stone practically almost free from pores, while the others are porous. However, not a sufficient number of duplicate tests were made to give the results the value they should have, as it was not known with what care nor with how many duplicates the tests were made at Watertown.

Comparative tests made on oolitic limestone from two localities by the first and third methods given above show 2.65 and 2.65 by the first and 2.48 and 2.46 by the third method, a very perceptible difference.

Greater care is necessary in making comparisons between porous stones than between the hard and dense ones. Thus the Hummelstown and the Connecticut stones by different methods show a difference of .3 equal to nearly 19 pounds on the foot, while tested by the same method the difference is only .02, a little more than one pound. As a rule those specimens having a low specific gravity *have a high absorption.*

The weight per cubic foot where not otherwise specified was obtained by multiplying the specific gravity by 62 1-2 the weight of a cubic foot of water.

Absorption tests. — The value of the absorption tests is in showing the porosity of the stone. Other things being equal the more porous the stone the greater the danger from frost. That is of two stones similar in all other respects but porosity the more porous one is liable to crumble first. Like all other tests, however, it is valuable only when taken with the other properties of the stone, as in many probably in most cases other properties are not equal, and it is not always safe to say that one stone is not so durable as another because it is more porous. It is to be regretted that more tests of this character are not available for comparison. All that could be obtained are given in the following table. The absorption of the Laurel Run stone as may be seen is remarkably low, while that of the Hummelstown stone is below the average for sandstone. In the list of building stones published by Gilmore the specimens of sandstones from different regions range from 1 in 15 to 1 in 70, with most of them below 1 in 30 and a great many below 1 in 20.

Crushing tests of Brownstone. — On the accompanying tables all the reliable crushing tests that could be obtained on the brownstones of Pennsylvania are given, along with the tests on brownstones from other localities for comparison. The authority is given in each case.

The White Haven stone, the Laurel Run stone, and the Lumberville stone run far above any of the sandstones in crushing strength as might be expected from their quartzite character. There are few quartzites with which to compare them. The Potsdam stone (No. 19) is quartzitic but the result is so abnormally large as to be useless for comparison. The only other quartzite in the market among building stones known to the writer is the Sioux Falls stone, no tests of which are at hand. The Medina sandstone of New York is very hard and possibly more or less quartzitic.

The crushing strength of the true sandstone as shown on the accompanying list and other lists, ranges from 3,000 to 12,000 pounds per square inch, only two on the list outside of the Hummelstown stone ranging as high as 13,000 pounds. One of these is the Medina stone which may be quartzitic, and one from Cromwell, Conn. The Hummelstown stone is above the average brownstone in crushing strength as is the Birdsboro stone, both of which are as hard as is consistent with ease of working. The Birdsboro stone in crushing gave way all at once and quietly, while the Hummelstown stone gave way with a loud report, all of the specimens giving a good pyramid at the top and some a pyramid at the base, but the *latter was generally* shattered in the explosion.

There is a false impression among stone dealers and others in regard to the signification of the crushing test. The desire seems to be almost universal to have a crushing test as high as possible. Objection was raised by one company to the publication of some results because they thought they were not high enough. A high crushing test signifies in general a hard rock, but hardness is not the most desirable quality in a building stone, in fact it is not always a desirable one; on the contrary it may be an objection. With rare exception a stone that is hard to crush in the machine is correspondingly hard to crush, cut, carve or break under the stone cutter's tool.

The idea that high crushing strength shows great durability, while a common one among dealers, is a mistaken one. Hardness or great strength, while a frequent accompaniment of durable stone, is not always so, nor are all hard stones durable ones. After a careful study both in the field and in the laboratory, the writer is satisfied that one of the sandstones on the accompanying list among the very lowest in crushing strength is among the most durable ones.

There are some sandstones so soft when first quarried that they may be easily crushed in the hand in small pieces, but they will stand exposure where not subject to abrasion better than many of the hardest rocks.

Some of the useful things which crushing tests if properly made show are the uses for which the stone is fitted. Thus a stone with a crushing strength of less than 6,000 pounds per square inch is not suitable for paving blocks, sidewalks, steps, or any place where it will be subject to wear. On the other hand it may be easily cut and carved and for most building purposes it may be one of the best and most durable stones. Again a stone with a crushing strength of more than 14,000 or 15,000 pounds per square inch is too hard for easy cutting or dressing and is not suitable for carved work but might make good paving material or rock face work. Uniformity in the results indicates homogeneity in the stone, a useful and important property. A great difference between samples tested on the bed and those on edge indicates a degree of lamination which renders it unfit for carved work or projections. A similarity of results between tests on the bed and on the edge show a freestone character. A low crushing strength for an apparently hard stone indicates inherent weakness, probably in the shape of weather,—powder,—or hammer-cracks, or clay secretions.

In comparing the results on the accompanying list or on any other list it is advisable to keep in mind that strength per square inch does not vary directly with the difference in area. That is a cube 2 inches on each side is more than four times as strong as a one-inch

Table showing crushing strength, specific gravity, and ratio of absorption of brownstones.

No.	Quarry.	Locality.	Crushing strength per square inch.	No. specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Authority, or the place where tested.
1	George Brook's,	Birdsboro, Pa.,	11,448	3				State College, Pa., 1897.
2	Hummelstown Brownstone,	Waltonville, Pa.,	14,753	3				Watertown Arsenal, 1897.
3	Hummelstown Brownstone,	Waltonville, Pa.,	14,000	3				Rose Polytechnic Institute, 189..
4	Hummelstown Brownstone,	Waltonville, Pa.,	12,730	8				Riehle Bros., 1897.
5	Hummelstown Brownstone,	Waltonville, Pa.,	13,100	3				Riehle Bros., 1890.
	Hummelstown Brownstone,		13,210	....	(1)2.35	146.6	1-27	Merrill—Stones for Building and Decoration, p. 413.
	Hummelstown Brownstone,	Waltonville, Pa.,		....	2.66	166.1	1-37	State College, 1897.
6	Lumberville quarries,	Lumberville, Pa.,	19,895	4			1-93	Fairbanks' laboratory, N. Y.
7	Lumberville quarries,	Lumberville, Pa.,	24,625	2	2.60	162.5	1-88	Booth, Garret & Blair, Philadelphia.
8	Lumberville quarries,	Lumberville, Pa.,	22,025	8				Garrison & Olsen.
9	Oliver's quarries,	Laurel Run, Pa.,	22,250	....	2.66			Columbia College School of Mines.
10	Oliver's quarries,	Laurel Run, Pa.,	17,600	12	2.66	166.0	1-900	Cornell University.
11	Oliver's quarries,	Laurel Run, Pa.,	23,600	1	2.66	166.0		Cornell University.
12	Jno. Daneker's quarry,	White Haven, Pa.,	29,252	3				Watertown Arsenal.
13	Jno. Daneker's quarry,	White Haven, Pa.,	32,397	1				Watertown Arsenal.
13	Portland quarries,	Portland, Conn.,	12,580	6	2.35	146.9	1-40	Watertown Arsenal.
14	Portland,	Middletown, Ct.,	6,250	2	(2)2.63 2.36 (2)2.68	148.5	1-40	Gen. Gillmore, Chief of Eng., Rep. 1875.
15	New England Brownstone Company,	Cromwell, Ct.,	16,894	2	2.50	156.0	1-40	Watertown Arsenal.
16	James & Marra, red,	E. Longmeadow, Mass.,	12,210	....	2.49	154.5	1-23	Watertown Arsenal, July, 1893.
17	James & Marra, brown,	E. Longmeadow, Mass.,	12,330	....	2.48	154.5		Watertown Arsenal, July, 1893.
18	Worcester quarry, brown,	E. Longmeadow, Mass.,	10,936	2	2.49	155.3	1-19	Watertown Arsenal, December, 1883, 6-inch cube.
19	Maynard quarry, red,	E. Longmeadow, Mass.,	10,274	1	2.49	155.3	1-20	Watertown Arsenal, March, 1889, 6-inch cube.
20		Medina, N. Y.,	16,031	2	2.40	150.0	1-53	Gen. Gillmore, 1875.
21		Little Falls, N. J.,	9,500	2	2.25	140.6	1-34	Gen. Gillmore, 1875.
22		Potsdam, N. Y.,	42,800	1	2.60	162.3	1-48	School of Mines, Columbia College.
23	J. B. Lyne & Sons,	St. Anthony, Ind.,	3,000	....			1-13	Rose Polytech. Inst., Terre Haute, Ind.
24		Marquette, Mich.,	10,780	....			1-50	Stone, June, 1894.
25		Marquette, Mich.,	5,992	3	2.29	142.8	1-32	Gen. Gillmore.
26		Marquette, Mich.,	6,150	6	2.16	135.3	1-20	Gen. Gillmore.
27		Marquette, Mich.,	3,800	....				Geol. Survey of Mich., 1891 & 1892.
28		Portage Entry, Mich.,	7,300	....	2.54	158.2	1-11	Stone, June, 1894.
29		Portage Entry, Mich.,	6,350	....				Geol. Surv. of Mich., 1891-92.
30		L'Anse, Mich.,	10,645	....				

		Keweenaw Bay, Mich.,	10,645	....	.....	.....	.....	Stone, June, 1894.
31	.....	Bass Island, Wis., ...	4,662	3	2.04	127.5	1-15	Gen. Gillmore.
32	.....	Fond du Lac, Wis., ...	6,237	2	2.22	138.8	1-22	Gen. Gillmore.
33	.....	Houghton, Wis., ...	7,316	2	.....	.....	.....	Columbia College, School of Mines.
34	.....	Wilson Island, ...	7,548	1	.....	150.0	.....	
35	.....	Fond du Lac, Minn., ...	8,750	....	2.25	141.3	.....	The Geol. of Minn., Vol. I, p. 209.
36	Minnesota Sandstone Company, ...	Kettle River, Minn, ...	12,547	2	.....	.....	.....	Watertown Arsenal.
37	.....	Edinburgh, Scotland, ...	11,625	2	2.26	141.3	1-34	Gen. Gillmore.

(1) A. Julien—Decay of Building Stones of N. Y. city.

(2) Made in Chem. Lab. Penna. State College.

cube, or stronger than four one-inch cubes placed side by side. Gillmore has computed the increase from a series of experiments on different sized blocks to be in proportion to the cube roots of the sides, thus giving a decided increase in result for the large specimens over the smaller. That is, a sample of a stone tested in a 4-inch cube would give double the strength per square inch that a sample 1-2-inch cube would give. But the desire to get as large results as possible induce both the dealers and the ones making the test to take as large a specimen as possible and divide the total stress by the area of crushing surface. On the accompanying table while most of the specimens were 2-inch cubes some were larger, but as the sizes of a number of the specimens could not be obtained none of them are given. Also tests made at different places by different operators on the same stone will give different results. So that comparisons should not be too rigid until the different conditions are considered.

Fire tests. — Tests were made in the assay laboratory at State College on samples of sandstone from different localities in the State to show its fire-resisting properties. There were samples from Hummelstown quarries, from the Middletown and Hummelstown quarry, from Birdsboro, Mohnsville, Grenoble, White Haven and Laurel Run. Along with these for comparison were specimens of the Potsdam sandstone, New York, the green serpentine from Thornbury and the oolitic limestone from Indiana.

The specimens were first heated in the oven until zinc melted on their upper surface, about 777° F., and some were cooled in air and some in cold water, all of the specimens being uninjured.

They were then heated until aluminum melted on the upper surface, about 1,157° F., but, the oven being much hotter at one end than the other, some were at a higher temperature. The limestones showed traces of calcination by a thin coating of lime in spots over the surface. The sandstone from the Middletown and Hummelstown quarry was perceptibly softer and brighter colored. The Hummelstown and the Mohnsville stones were brighter colored, but the texture and strength seemed unchanged.

The specimens were then heated until sodium chloride melted on their upper surface, nearly 1600° F., while many of them were exposed to a higher temperature, a bright red heat. The limestone was calcined to quicklime; the serpentine had lost its green color and cracked in several places; the Middletown and Hummelstown stone was a light red color and quite soft and friable. The Hummelstown stone was a brighter red, but was not cracked even with cold water, and apparently nearly if not quite as strong as before heating. The Mohnsville had changed its dark brown color to a *bright red* brown. The Birdsboro pink sandstone and the Grenoble

stone showed no effect of the heat in any way. The White Haven and Laurel Run red stone changed color to a darker brown and duller color, but the texture was uninjured.

The tests were not carried further, but this is sufficient to show that these sandstones, which are fairly representative specimens, are excellent fire-resisting stones. No tests were made on the more aluminous stones of the Delaware valley. The stones tested, while possibly not absolutely fire-proof, are more nearly so than a great many stones in the market. In few ordinary fires will the stone be subject to a temperature higher than 1600° F., which the different stones stood without injury except in the color of some specimens.

Occurrence of brownstones in Pennsylvania. — The brownstones, so far as commercially developed, are confined largely to the eastern and southeastern part of the State. The New Red area, in which most of the quarries are located, as shown on the accompanying map, extends from the Delaware river north of Trenton in an irregular rather broad belt west-southwest through Bucks, Montgomery, Berks, Chester, Lebanon, Lancaster, Dauphin, York and Adams counties. The most productive quarries are those near Hummelstown. Other less productive quarries are at Mt. Gretna, Schaefferstown, Mohnsville, Birdsboro, Phoenixville, Valley Forge, Port Kennedy, Fort Washington, Norristown, Grenoble Station, Neshaminy, Newtown, Yardley and Lumberville. Quarries of considerable size near Middletown and Goldsboro were once productive, but are now abandoned. There is a sample in the World's Fair collection from Adamstown, Lancaster county, but it is not known whether the quarry is in operation now or not.

The Mauch Chunk formation, from which red-brown quartzose sandstone is obtained, surrounds the anthracite coal basins in the eastern part of the State, and, according to the State geological map, underlies the coal measures of the west and west central portion of the State. So far as is known to the writer, the only places that the Mauch Chunk red stone has been quarried are the southern part of the north anthracite field and the east end of the middle field at Mocanaqua, Laurel Run and White Haven. A brownstone has been quarried near Rockwood, Somerset county, that may be from this formation, but no definite information is at hand concerning it. A brownstone used for building purposes is quarried at Ellwood City, in the west part of the State, but to what extent is not known. It is presumably of Carboniferous age, but no particulars in regard to the quarry are at hand.

There is brownstone in the Catskill, Clinton and Medina groups in Pennsylvania, but so far as known no quarries have been opened in any of them. Time did not permit a personal examination of these areas, to see whether good stone occurred in commercial quantities or not. The fact that there are many productive quarries in

the Medina formation in Western New York and the promising appearance of the few outcrops observed in this State would suggest the possibilities of good brownstone from one or both of these formations. The following list contains all the brownstone quarries known to the writer in the State:

List of the brown and red stone quarries in Pennsylvania.

(Numbers correspond to numbers on the map).

Numbers 1-42 are in the New Red area.

1. Reehling quarry, 2½ miles west of Goldsboro—1851-'56, Thomas Symington; 1856, Geo. Betz, J. H. Killwell; 1869-'70, Frazer and Reehling; 1870-'80, C. F. Reehling. Now idle.

2. Middletown and Hummelstown quarry, a mile north of Middletown—Middletown and Hummelstown Co., now in the hands of a receiver.

3. Pennsylvania Brownstone Co.'s quarry, 2 miles south of Hummelstown—1886-1890. Idle since that time

4. Hummelstown Brown-Stone Co., Waltonville, 3 miles southeast of Hummelstown, 1800 to the present. 4 quarries —1800-1860, local; 1860-66, Henry Brown; 1866-1877, Pennsylvania Brown Freestone Co., 1877-'97, Hummelstown Brown-Stone Co.

5. Co-operative Brownstone Co.'s quarry, a half mile east of Waltonville, new small opening, now idle.

6. Stoverdale Brownstone Co's quarry, ¼ mile south of Waltonville, 1895, now idle.

7. Hummell quarry, a mile south of Waltonville, now idle.

8. American Brownstone Co., 2 quarries, 1¼ miles south of Waltonville, 1890-1893.

9. Swatara quarry, a mile south of Hockersville, 1894-1895.

10. Derry quarry, 2 miles south of Hockersville—Francis, Painter & Co., 1884-1888.

11. Mount Gretna quarry—A. G. DeHuff.

12. Local quarries, south of Schaefferstown, operated by Joseph Watson and others, thirty years or more.

13. Thurber and Wiegel quarries, south of Kleinfeltersville.

14. John Westley's quarry, 2 miles southwest of Mohnsville—1886-'97.

15. Amos Price's quarry, 2 miles southwest of Mohnsville—1883-'97.

16. Daniel Shonour's quarry, 2½ miles southwest of Mohnsville—'97.

17. Brooks' quarry, 2 miles south of Birdsboro. Other smaller quarries in the vicinity. Idle.

18. Mount Clare quarry, on the hill above Mount Clare—'97.

19. Malin Miller's quarry, Phoenixville. Idle.

20. Newton Walker's quarry, ½ mile east of Perkiomen Junction. Idle.

21. Charles Johnson's quarry, a mile east of Valley Forge—1897.

22. Port Kennedy Stone Company, Betzwood, opposite Port Kennedy—'97.

23. Port Indian quarry, on the Pennsylvania Railroad near Port Indian. Idle.

24. Derr quarry, west side of Norristown. Other local quarries. Idle.

25. John Brown's quarry, ½ mile west of Bridgeport, Norristown—'97.

26. Schenlein quarry, ½ mile west of Bridgeport, Norristown—'97.

27. Tyson's quarry, ¼ mile west of Bridgeport, Norristown—'97.

28. Local quarry, east side of Norristown.

29. Kennedy's quarry, ½ mile north of Fort Washington—'97.

30. Wallace's quarry, ½ mile north of Fort Washington. Idle.

31. Frog Hollow quarry—Joseph Paul, 1876-'97; ½ mile south of Neshaminy post office.

32. Loux quarry, A. P. Loux, Tradesville, 2 miles southwest of Doylestown—'97.

32a. Grenoble quarry, Grenoble station—1891, by Jameson & Ryan; 1892-'93, J. J. Ryan; '95-'97, Moody and Edwards.

33. Mitchell quarry, Newtown—1868-9, S. Prior & Co.; 1869-'72, Prior & Son; 1882-'97, Henry Mitchell.

33a. Watson's quarry, Newtown—1894-'95, Chas. Watson. Idle.

34. Nicholson quarry, ½ mile west of Yardley—Operated for a number of years by Twining Bros.; later by James Shevlin; now idle.

35. Yardley quarry, ½ mile north of Yardley—1873-1882, by Henry Mitchell; 1888-'97, by James Shevlin.

36. White quarry, 2 miles north of Yardley—Wm. White—'97.

37. Local quarries, along the canal south of Yardley; now idle.

38. Carversville quarry, Carversville—1881-'85, by Twining Bros.

39. Conner's quarry, a mile south of Lumberton—1890-'97 Thos. J. Conner.

40. Sampsell quarries, a mile south of Lumberton—J. M. Sampsell.

41. Paxson's quarry, Lumberton—1880-'97, W. S. Paxson.

42. Quarries of the Lumberville Granite Co., Lumberton, a mile below Lumberville—'97.

The following are in the Mauch Chunk Red Stone:

43. Reiser and Doland quarry, west bank of the Lehigh river, 3 miles below White Haven, near Drifton Junction—1894-'97, by Reiser and Doland, Wilkesbarre.

44. Cooper Bros.'s quarry, west bank of the Lehigh river, 2 *miles below White* Haven—Cooper Bros., 1892-'97.

45. John Redington & Co.'s quarry, east side of the Lehigh river, 1 mile below White Haven—'97.

46. Fox quarry, on the west side of the Lehigh river, opposite No. 45. Idle.

47. Daneker's 3 quarries, west side of the Lehigh river, 2 miles above White Haven—1873-1897, by John Daneker.

48. Schmitt's quarries, Laurel Run, 3 miles south of Wilkesbarre—'97. Other quarries adjoining not in operation.

49. Elbow quarry; several small quarries at and near the Elbow on the Central Railway of New Jersey, 2 miles south of Wilkesbarre; only one in operation at present.

50. Mocanaqua quarry, a half mile above (N. E. of) Mocanaqua; idle.

The following quarries are not shown on the map.

51. Somerset Brownstone quarry, near Rockwood, Somerset Co.—Operated by J. C. McSpadden.

52. Ellwood City quarry—Operated by Wilson Bros. & Co., Ellwood City, Lawrence County.

Methods of quarrying and handling the brownstones.—In all of the small quarries throughout the State the work is mostly done by hand, and frequently with liberal (entirely too liberal) use of powder. Holes are drilled by hand either with the churn drill or jumper, and heavily charged with powder and fired, loosening sometimes a large quantity of stone. If the loosened blocks are too large to be broken by repeated blows with a heavy hammer, another charge of powder is put in and the demolition completed.

As may be well imagined, but little good dimension stone is quarried in this manner. Yet much stone that would be good dimension stone if properly quarried is taken out in this way. Where good dimension stone is required it is taken out by splitting the blocks from the ledge with wedges (plugs and feathers), or by the Knox blasting system, or some similar system. Channeling machines are not used in any of the brownstone quarries of the State. Nor is the stone in any of them in such shape as to require or justify their use. There are numerous seams in all of the quarries, either bedding or joint seams, and by utilizing these seams the stone can be extracted more cheaply by wedging and blasting than by channeling. In the larger quarries the Knox system of blasting is used, which, if properly managed, reduces the injury to the stone almost to a minimum.

The Knox blasting system, which is patented, consists essentially of making a series of elongated holes along the line of desired fracture, putting in a light charge of powder, leaving an air chamber *between the powder* and the confining plug and firing all simul-

taneously with an electric battery. It requires a special reamer to make the drill hole oval or elongated, or the hole may be made by boring two holes side by side and breaking down the wall between them. The Githens system claims to be an improvement over the Knox system of having a drill that will make a hole of the required shapes in one operation. One advantage in this system of blasting is the great saving of stone, and another is the improved quality of the stone, as it is not subject to the jar of such a heavy blast. In the old system the hole was drilled and loaded with a heavy charge of powder that would generally loosen and greatly shatter the rock, but there was no means of directing the force so that very irregular blocks were produced, with a great waste of rock and time and energy in squaring them. In the new system the elongated holes direct the line of fracture with the greatest diameter of the hole, and the stone is broken into rectangular blocks, the regularity of which depends on the number of holes and the character of the rock. Some stone is much straighter in the grain than others, and requires fewer holes to make a straight break. Thus, the Lumberville stone is readily broken by holes two or three inches deep, while to make a break equally straight in the Yardley stone would require the holes to be drilled nearly through the block to be broken. The number and depth of the holes necessary for a straight break is learned by experience in the different quarries.

Where the rock occurs in regular layers, after once getting a straight face successive blocks are broken off by putting a row of holes parallel with the face and firing with a battery. The channeling machine may be used to advantage in cutting out the ends of the quarry, or if on a long face, making cross-cuts.

While there is no question that this method of quarrying is an improvement over the old method of blasting, it still does not do away entirely with the injury that comes from blasting the stone, and while in many instances it would be more expensive to remove the stone by channeling and wedging, the stone would be all the better for being so quarried.

In all small quarries the stone is loaded on the wagon, car or boat by hand, or with the use of a hand-power or horse-power derrick. The large quarries have steam hoists. The Hummelstown Brown Stone Co. has 36 derricks erected, besides two wire cable ways, and steam travelers at the mill. They have also a large steam shovel for handling the waste and a railway track through the yard and to all parts of the quarries. The only other brownstone quarries in the State that use steam power are those of the Lumberville Granite Co., at Lumberville; John Schmitt's quarries, at Laurel Run, and John Daneker's quarries, at White Haven. The first named has a wire cable with a carrier run by steam across the Delaware river to

deliver stone to the railway. The Middltown and Hummelstown quarry, near Middletown, is equipped with steam and electric plant, but it is now idle, and has been for several years.

Nearly all the quarries in operation are near the railway or the canal. The shipping facilities of each is mentioned in the description of the quarry.

Uses and adaptability. — Brownstones are used for almost all classes of work for which any other rock is used. It is pre-eminently a building stone, probably one of the most valuable in the market, and adapted to as many different classes of structural uses as any other. In Pennsylvania, besides its use as a building stone, it has been used as sand for plastering, masonry, and pig beds in the furnace, for furnace hearths, lining blast furnaces, monuments, paving blocks, curbing, flagging, stepping stones, macadam and concrete. But by far the larger part quarried goes into structures of some kind: The better qualities into superstructures as walls or trimmings and the inferior grade into foundations, bridge piers and abutments, culverts, retaining walls, etc. The different varieties are all adapted to these different uses if selected with care. Thus, where the stone is to be carved or smooth-dressed a fine grained stone of homogenous color and not too hard should be selected; for rock-faced work and heavy masonry the coarse-grained can be used; but all kinds are suitable that are sufficiently strong and durable; in bridge piers and foundations mixed stone, that is, stone variegated in color and texture, may be used. In nearly all quarries there is considerable stone that may be as strong and durable as any, but is lacking in beauty or homogeneity, and cannot be used as first-class stone in superstructures, but which can be used to advantage in bridge work, where strength and not beauty is required.

Soft stones like those from Newtown and Yardley are admirably adapted for building in face work or for heavy trimmings, but will not stand the wear in pavements and streets, or heavy cross-strain in lintels and sills, unless protected in some way. Stones like those from White Haven, Wilkesbarre and Lumberville are sufficiently hard not only for foot wear in pavements, but for street wear as Belgian blocks or crushed stone. On the other hand, they are not adapted to buildings where much cutting or carving is to be done on account of their hardness. A stone with weak transverse strength should not be used for lintels, sills, caps, etc., where it is subject to strain unless well protected by over-arching or by other means. It is not advisable to put a soft or porous stone in the foundation or base-course if it can be avoided. The most trying place for a stone in the entire building is in the part next to the ground, where the moisture absorbed from the earth is repeatedly frozen. This part of the building should have the most compact and least absorbent stone, and should be laid with the best cement.

Lutheran Church, Hummelstown, Pa.
Hummelstown brownstone.

St. Nicholas German Catholic Church, Wilkesbarre, Pa. Laurel Run red stone.

Presbyterian Church, Bloomsburg, Pa.
Hummelstown brownstone.

SHOWING THE USE OF PENNSYLVANIA BROWNSTONES IN CHURCHES.

To obtain the best architectural effects care must be taken in selecting the colors. This is largely in the hands of the architects and the contractors, but when they persist in putting up entire blocks of dark brownstones along narrow streets, it is time that owners and residents should protest. Some shades of brownstones are pretty in themselves, others have their natural beauty intensified and brought out by judicious mingling with other colors and shades.

The lighter colored brownstones could be used in larger quantities, either in the same building or the same town, with more pleasing results than the dark colored, but the two together will produce a better effect than either alone. The darker stones are better adapted to business blocks on the principal thoroughfares, as they do not soil or show stain so readily. The lighter colored ones are adapted to residences in the suburbs or country towns.

The very hard quartzite varieties should not be used in excess in face work on large, unbroken surfaces, as the hard, stony glare produced by them is repellent. On a large face this could be relieved in part by an intermingling of sawed or tool-dressed faces among the rock-faced ones.

Plates 3, 4, 5, 6, 7, 9, 11, 12, 14, 15, 16, 17 and 19 show some of the architectural uses of Pennsylvania brownstones, and the following pages contain a list of many of the buildings constructed of the native brownstone. This will give an idea of the extent of the industry, the varied uses and adaptability of the stone. It will show that the usage is more than local. The primary object of the list, however, is to enable architects, builders and others to see where the stone has been used that they may judge by observation in regard to its beauty and adaptability, as a building shows much more than a hand sample. The attempt was made to have the list sufficiently extended and specific that persons in any part of the State, or the adjoining states, would know where to turn to buildings of Pennsylvania brownstone without travelling far. Where the part of the building in which the stone was used is not known a question mark is placed.

BUILDINGS CONSTRUCTED OF PENNSYLVANIA BROWNSTONE.

Giving the location of the building, the architect and the part of the building in which the stone is used, where known, and the quarries from which the stone was obtained. An ? signifies that the part of the building and the architect are not known to the writer.

PENNSYLVANIA.

Allentown:
High school, base, entrance and trimmings. H. B.-S. Co.*
Robert E. Wright's residence. ? Lumberville quarries.

Ambler:
Presbyterian church, entire. Fort Washington quarries.
Godfrey Hotel, entire. Fort Washington quarries.
Mrs. Reed's residence, entire. Fort Washington quarries.

* In this list H. B.-S. Co. signifies that the stone is from the quarries of the Hummelstown Brownstone Company.

Bethlehem:
Hon. John Fritz, residence, base, entrance, porches and trimmings. H. B.-S. Co.
Bloomsburg:
Columbia county court-house, base, entrance and trimmings. H. B.-S. Co.
Presbyterian church, entire, facings and trimmings. H. B.-S. Co.
Carlisle:
Denny Hall, Dickinson College, entire, facings and trimmings. H. B.-S. Co.
Bosler Hall, Dickinson College, base, first story, entrance porch and trimmings. H. B.-S. Co.
Jail. ? Goldsboro quarry.
Catasauqua:
High school base, entrance and trimmings. H. B.-S. Co.
Chaderocksville:
School house. ? White Haven quarries.
Cornwall:
Robt. Coleman's mansion and the North Cornwall railway station, numerous dwellings and office buildings about Cornwall, entirely from local quarries.
Danville:
Hospital for the Insane. ? Goldsboro quarry.
Opera-house. ? Goldsboro quarry.
Doylestown:
Court-house, facings. Lumberville quarries.
Court-house, trimmings. Yardley quarry.
Easton:
Presbyterian church. ? Yardley quarry.
Rosenbaugh, residence. ? Lumberville quarries.
Grant, residence. ? Lumberville quarries.
Eddington, Phil'a:
Industrial school. ? Newtown quarry.
Emporium:
Cameron county court-house, base, entrance and trimmings. H. B.-S. Co.
Fort Washington:
Lutheran church, J. M. Kennedy's residence and a number of other residences. From the Fort Washington quarries.
Gettysburg:
Pennsylvania College, base, doorway and trimmings. H. B.-S. Co.
Lutheran Theological Seminary, base, entrance, porch and trimmings. H. B.-S. Co.
Brua Memorial church, base, tower base, entrance and trimmings. H. B.-S. Co.
Hazleton:
High school building, base, entrance and trimmings. H. B.-S. Co.
Church Street school, base, entrance and trimmings. H. B.-S. Co.
Harrisburg:
Grand stairway, entrance to the State Capitol.
Westminster Presbyterian church, entire. C. W. Bolton, architect.
Pennsylvania Railroad Station, base and trimmings.
Administration building, State Insane Asylum, porch, columns, caps, entrance and trimmings.
High school building, the entrance and all the trimmings above the base.
Harrisburg Club, the base, first story, entrances and trimmings.
Governor's Mansion, front. All the above from H. B.-S. Co.
State Arsenal, C. L. Bailey, and Rudolph Kelker's residences. From Goldsboro quarry.
Holmesburg, Phil'a:
St. Dominic church, doorways and trimmings. Newtown quarry. Steps and sills. H. B.-S. Co.
Hummelstown;
Lutheran church (J. A. Dempwolf, architect), entire, facings and trimmings. H. B.-S. Co.
Huntingdon:
Huntingdon Reformatory base entrances and trimmings of administration building, base, water-tables and trimmings of wards, base, water-tables and trimmings of walls. H. B.-S. Co.
Kingston:
Public school building, base, entrance and trimmings. H. B.-S. Co.
Music Hall. ? White Haven quarries.
Lancaster:
German Reformed Theological Seminary, base, doorways and trimmings. H. B.-S. Co.
People's Bank, entire front of dressed stone. H. B.-S. Co.

Lock Haven:
Central State Normal School, steps, water-table and all trimmings. H. B.-S. Co.
Mansfield:
Mansfield Normal School, base, water-table, main entrance and trimmings. H. B.-S. Co.
Mauch Chunk:
Carbon county court house, facings from the White Haven quarries. Doorways and trimmings. H. B.-S. Co. (See Plate 5.)
Middletown:
Pennsylvania Railroad bridge, W. H. Brown, engineer. H. B.-S. Co.
Millersville:
Scientific building, State Normal School, entrance and trimmings. H. B.-S. Co.
Library building, State Normal School, entrance and trimmings. H. B.-S. Co.
Mount Holly:
Library, entire, facing and trimmings. H. B.-S. Co.
Newtown:
First National Bank, Presbyterian chapel, Methodist church, addition to the public school, residences of George Black, Samuel C. Case, Thos. Briggs, Mrs. John Copper, all built entirely of stone from the Newtown quarry.
Norristown:
Haws Avenue M. E. church, water-table, steps and trimmings. H. B.-S. Co.
One church, several residences and part of the high wall around the Catholic school, of stone from the local quarries.
Philadelphia:
Residence of Mr. Ellis, W. H. Decker, architect; entire front and approaches of dressed and carved stone.
Residence of Mr. Frazier, base and trimmings.
Residence of Mr. Drexel, base, entrance and trimmings.
Buildings of University of Pennsylvania, base, doorway and trimmings.
Medico-Chirurgical College, base, entrance and trimmings.
Hahnemann College, base, approaches and all trimmings.
St. Mathias church, facings and trimmings.
Holy Communion church, base and trimmings.
German Society building, base, doorway and trimmings.
Young Maennerchor building, base, doorway and trimmings.
Philadelphia Bourse, approaches and base.
Bullitt building, G. W. and W. D. Hewitt, architects; doorways, entire first story and trimmings above.
Academy of Fine Arts, base, aproaches and other brownstone trimmings.
Academy of Natural Sciences, base and brownstone trimmings.
Frankford pumping station, Tacony, Philadelphia, base and trimmings.
Spring Garden pumping station, base and trimmings.
Philadelphia Library, trimmings.
Philadelphia and Reading Railway Station, Frankford, Philadelphia, base, entrance and trimmings. This and all the above of H. B.-S. Co.
Philadelphia Traction Company power house, Market street, foundation and trimming from Lumberville quarry.
German Hospital, Girard and Corinthian avenues; all face stone. Newtown quarry.
Episcopal Hospital, Front street and Lehigh avenue; face stone. Newtown quarry.
Methodist Hospital, Broad and Wolf streets. ? Newtown quarry.
Parochial school and parsonage for St. Anne's church, Lehigh avenue and Cedar street. ? Newtown quarry.
Convent of the Good Shepherd, Chew street, Germantown, Philadelphia. Newtown quarry.
Pottsville:
Garfield school, base, entrance and trimmings. H. B.-S. Co.
Public school building. ? Goldsboro quarry.
Tenth census, 1880, says the Goldsboro brownstone is used in two or three buildings, and that the Hummelstown brownstone is the stone chiefly used for trimmings, being in every way satisfactory.
Reading:
First Baptist church, trimmings, steps and approaches. H. B.-S. Co.
Home of the Good Shepherd, base, water-table, entrance and trimmings. H. B.-S. Co.
Court-house. ? Mohnsville quarry.
Keystone Bank, on Penn above Sixth. ? Mohnsville quarry.
Stevens building. ? Mohnsville quarry.

Reading—continued:
Residence of John Barby. ? Mohnsville quarry.
Several school houses. Mohnsville quarry.
Residence of J. H. Sternbergh,. all face stone. Local quarries, pink stone, south of Birdsboro. (See Plate 19.)
Chapel and entrance buildings of the Chas. Evans Cemetery. Mohnsville quarries.
Schaefferstown:
Thurber's residence, entire from local quarries south of town.
Weigle's residence, entire from local quarries, south of town.
Scotland:
Soldiers' Orphan Industrial Home, base, entrance and trimmings. H. B.-S. Co.
Scranton:
Public school building, entrance, water-table and trimmings. H. B.-S. Co.
Laurel Run redstone, said to be used in Scranton, but no buildings specified.
Shamokin:
Trust building, base, entrance and trimmings. H. B.-S. Co.
Shippensburg:
State Normal School. ? Goldsboro quarry.
State College:
Engineering building, base, entrance and trimmings. H. B.-S. Co. (See p. 50.)
Steelton:
Foundation for machinery and blooming mill and for Bessemer engine. Goldsboro quarry.
Sunbury:
Public school building, base, entrance and trimmings. H. B.-S. Co.
Williamsport:
Susquehanna trust building, base entrance, piers and trimmings above. H. B.-S. Co.
Williamsport Hospital, water-table, steps and trimmings. H. B.-S. Co.
Torresdale, Phil'a:
Eden Hall. ? Newtown quarry.
Wilkesbarre:
City Hall, base, first story, entrance and trimmings above first story. H. B.-S. Co.
Y. M. C. A. building, entrance, first story, piers and all trimmings. H. B.-S. Co.
St. Nicholas German Catholic church, entire, William Schickel, architect. Laurel Run Redstone quarries. (See Plate 4.)
First Presbyterian church, entire, J. C. Cady, architect. Laurel Run redstone quarries.
Baptist chapel, entire. Laurel Run redstone quarries.
Residence of E. C. Frank, base and first story front, A. H. Kipp, architect. Laurel Run redstone quarries.
Residence of S. L. Brown, base and bay window, A. H. Kipp, architect. Laurel Run redstone quarries.
Ninth regiment armory, base, entrance and trimmings; M. B. Houpt, architect. Laurel Run redstone quarries.
A great deal of Laurel Run redstone used in Wilkesbarre for foundations, retaining walls, curbing, etc.
York:
Residence of Judge Stewart, base, first story, entrance and trimmings above. H. B.-S. Co.
Colonial Hotel, water-table, entrances, porches and trimmings. H. B.-S. Co.
United States court-house and post office, base, water-table, column caps, arches at entrances and trimmings. H. B.-S. Co.
York Collegiate Institute, all of the trimmings. H. B.-S. Co.
Residence of Mr. W. M. Kurtz, base, entrance and trimmings. H. B.-S. Co.
St. Paul's church. ? Goldsboro quarry.
Tenth census report, 1880, states that the Goldsboro brownstone was used to considerable extent.

FLORIDA.

Orlando:
Orange county court-house, approaches, water-table and trimmings. H. B.-S. Co.

MAUCH CHUNK COURT HOUSE.

Showing the use of Pennsylvania brownstones in public buildings. The face work of White Haven red stone, entrance and trimmings of Hummelstown brownstone.

ILLINOIS.

Chicago:
- Residence of Mr. Wellman, Beethoven Place, between Wells and Sedgwick streets, base and trimmings. H. B.-S. Co.
- Residence of Mr. King, Michigan avenue and Harrison streets, base and trimmings. H. B.-S. Co.
- Residence of John Heiland, 1506 Michigan avenue, base and trimmings. H. B.-S. Co.
- Residence of K. A. Shaw, Jackson and Laflin streets, base and trimmings. H. B.-S. Co.
- Residence of Mr. Nash, Ashland avenue near Harrison street, base and trimmings. H. B.-S. Co.
- Apartment buildings of Mr. Johnson, 212-216 Indiana street, base and trimmings. H. B.-S. Co.
- Mr. Keniston's building, Carpenter and Madison streets, base and trimmings. H. B.-S. Co.

INDIANA.

Indianapolis:
- Union Station, stone trimmings above base. H. B.-S. Co.

MARYLAND.

Gapland:
- Army Correspondence Memorial Arch, arches, tablets and trimmings. H. B.-S. Co.

Hagerstown:
- Administration building. ? Goldsboro quarry.

La Plata:
- Court-house, entrance, water-table and trimmings. H. B.-S. Co.

Rockville:
- Court-house of Montgomery county, entrance water-table and trimmings. H. B.-S. Co.

MISSOURI.

St. Louis:
- Residence of William Clark, base, entrance and trimmings. H. B.-S. Co.

NEW JERSEY.

Camden:
- Catholic Church. ? Yardley quarry.

Elizabeth:
- Senator Corvin's residence. ? Lumberville quarry.

Mount Clare:
- Residence of Col. Fellows, entire facing and trimmings. H. B.-S. Co.

Orange:
- M. E. church, entire facing and trimmings. H. B.-S. Co.

Princeton:
- Princeton College, trimmings to one of the buildings. Newtown quarry.

NEW YORK.

Belona:
- Belona Baptist church, water-table and trimmings. H. B.-S. Co.

Brooklyn:
- St. John"s Hospital. ? Lumberville quarries.

Clifton Springs:
- Sanitarium, approaches, porch, doorway, and all trimmings. H. B.-S. Co.

Elmira:
- Belgian blocks in the streets. White Haven quarries.

New York City:
- Market and Fulton National Bank. W. B. Tubby, architect, base, entrance and trimmings. H. B.-S. Co.
- Pottier and Stymus building, S. D. Hatch, front entirely of dressed, rubbed and carved stone. H. B.-S. Co.

OHIO.

Cleveland:
- Residence of Mr. S. F. Everett, C. F. Schweinfurth, architect, entire facing and trimmings. H. B.-S. Co.

Cleveland—continued:
Arcade building, G. H. Smith and Jno. Eisenmann, architects, entrances, first story piers, and cornice and trimmings above. H. B.-S. Co. (See Plate 15.)
Wade Bank, doorway, base and trimmings above. H. B.-S. Co.
Residences of Messrs. Warner and Swasey, base, entrances, porch and trimmings. H. B.-S. Co.
Dayton:
Residence of Col. Platt, base, entrance, porch and trimmings. H. B.-S. Co.
Salem:
Pennsylvania Railroad Station, base and trimmings. H. B.-S. Co.

VIRGINIA.

Abington:
United States court-house and post office, trimmings. H. B.-S. Co.
Leesburg:
St. James' church, entrances, water-table, and trimmings. H. B.-S. Co.
Washington, D. C.:
Residence of Senator Hurst, W. H. Miller, architect; base, porch, entrance, and trimmings.
Residence of Senator Sawyer, entire facing and trimmings.
Residence of Hon. Levi P. Morton, base, entrance and trimmings.
St. Joseph's Roman Catholic church, P. N. Dwyer, architect; entire facings and trimmings.
Richmond Flats—base, first story, and trimmings above.
Cochran Hotel—base, entrance and trimmings.
Albaugh's Opera House—base, first story, and trimmings above.
Albany Flats—base, first story, and trimmings above.
Bureau of Printing and Engraving—trimmings and entrance.
Residence of Hon. James G. Blaine, trimmings.
Residence of Senator John Sherman, trimmings.
Residence of Senator J. D. Cameron, trimmings.
Residence of Jerome Bonaparte, trimmings.

All the above Washington buildings are of H. B.-S. Co. stone. Goldsboro brownstone is said to have been used in Washington.

WEST VIRGINIA.

Bluefield:
People's Bank, entrance and trimmings. H. B.-S. Co.

Statistics. — The statistics of the brownstone production in Pennsylvania could not be obtained in a very satisfactory manner. Some of the quarries were not in operation at the time of my visit to them and the parties could not be seen personally. A few refused to give the production of their quarries; while some of the others would give only the average for the last six years. The figures of production that were obtained from the majority of active producers were combined with the averages given by others, and to these were added conservative estimates of the remainder. The figures obtained in this way are here given:

Value of brownstone produced in Pennsylvania since 1890.

	Values given by quarrymen.	Estimated values.	Total for the year.
1891,	$348,000	$69,000	$417,000
1892	353,700	82,000	435,700
1893,	346,900	80,000	426,900
1894,	340,400	71,000	411,000
1895,	351,200	70,000	421,200
1896,	325,000	55,000	380,000
Value of average yearly production since 1890.			$415,300

The above does not include any estimate on production of the quarries at Phoenixville, Mount Clare, Valley Forge and vicinity, Conestoga Valley, Mocanaqua, Rockwood, Ellwood City and the quarries in the vicinity of Hummelstown outside of the Hummelstown Brown-Stone Company, because there are not sufficient data available to give such an estimate any value. Nor does it include any estimate on the purely local usage of the stone where there is no established quarry. And this is an important source in the aggregate, as in Lancaster, Lebanon, Dauphin, York, Berks, Chester, Bucks and Montgomery counties there are a great many farm buildings and country residences constructed from stone taken from outcrops on the farm or immediate vicinity.

The estimates were based on comparison with other quarries in the same district, from the number of men employed, the uses to which the stone was put, the time it was in operation, the size of the opening and other things. The list above on which no estimates were given includes those quarries of which we had not sufficient data to make a rational estimate. From the information at hand I feel safe in saying that the value of the total production of brownstone in the State would be not less than $450,000 and possibly not less than a half million dollars per year. However, the distribution through the six years would be different from that shown on the table, as some of the largest producers gave their product only in the average annual output and as we had no data for distributing it, it was counted the same for each year. Hence the product for '95 and '96 would be less than that shown on the table and that for '91 and '92 much more making the yearly average the same.

PART II. LOCAL FEATURES OF THE BROWNSTONES OF PENNSYLVANA.

General features of the New Red area.—The New Red* is a name commonly applied in this State to a series of rock strata in southeastern Pennsylvania of age more recent than the Carboniferous and commonly supposed to correspond to the Triassic, and possibly Jurassic in part, division of the Mesozoic.

It forms a belt of varying width extending through southeastern Pennsylvania from New Jersey to Maryland and including nearly all of Bucks and Montgomery counties and parts of Chester, Berks, Lebanon, Dauphin, York and Adams counties. This forms but part of an outcrop extending along the eastern part of the United States between the Allegheny Mountains and Blue Ridge from Massachu-

*Dr. Lyman in his excellent treatise on the New Red of Bucks and Montgomery counties and in a paper in the Journal of Geology, gives reasons for retaining the name New Red in preference to Newark, Connecticut, Jurassic, Triassic, Mesozoic, and other synonyms.

setts to North Carolina but broken into separate areas.* The stone occurs and is quarried in Massachusetts, Connecticut, New York, New Jersey, Maryland, Virginia and North Carolina.

It is made up of a series of shales, sandstones and conglomerates, for the most part of red brown color but varying widely in different localities. Dr. Lyman as a result of his investigation in Montgomery county makes the total thickness of the whole series in that county 27,000 feet subdivided as follows:

	Feet.
Pottstown shales, red shale with a few scattered green layers,	10,000
Perkasie shales, green and dark red or gray shales,	2,000
Lansdale shales, red shales with a few scattered green layers,	4,700
Gwynedd shales, black, dark gray, and red or green shales,	3,500
Norristown shales, red shale, brown and gray sandstone and conglomerates,	6,100
Total,	27,000

As will be seen, the brownstone occurs in the lower group of the series according to this classification. No attempt was made in the present work to carry this correlation westward into the neighboring counties, or to correlate the different deposits found there, as there was not sufficient time available to give such work any value. The Mohnsville, Cornwall, Hummelstown, Goldsboro beds while they are thought to be the stratigraphic equivalent of the Norristown, Newtown, Yardley, Lumberville beds, they were not so proven and because of lack of time no attempt was made to prove whether the lower part of the series including the brownstone was of Permian age as thought by Dr. Lyman, or of more recent age as argued by other writers.

There has been considerable discussion about the apparently great thickness† of this formation in different localities. The only part that has a direct bearing on the present discussion is the thickness of the beds of workable sandstone and of the material separating them. The workable sandstone is in beds varying from a few feet to a hundred feet or more. If one includes the interstratified shale layers a thickness of several hundred feet might be obtained at either Lumberville or Hummelstown. There is probably a greater thickness of good stone in proportion to the amount of shale in the

* See maps in Dr. Lyman's report, Pa. Geol. Survey-Summary. Final Report, or in Bull., 85 U. S. Geol. Survey.

The reader is referred to Bull. 85 of the U. S. Geological Survey for a review *of the whole subject and* literature bearing upon it.

vicinity of Lumberville than in any other locality. At Newtown and Yardley the bed is 30 to 40 feet, at Grenoble and Fort Washington about the same. At Norristown it is 50 feet or more, at Mohnsville about 30 feet, at Hummelstown 50 feet, and at Goldsboro 12 to 15 feet. At most places where the sandstone occurs there is a succession of several beds separated by intervening beds of red shale and conglomerate, the value of the deposit depending upon the relative proportion, position, and character of the sandstones.

So far as known, the shales have no economic value further than that the harder forms are used in places for road metal and in two places, Mount Clare and Birdsboro, they have been used for building material.

Some writers have supposed that all the strata of the series have a uniform dip north to northwest of 10 to 25 degrees, but such has been shown not to be the case. While the west of north dip is the more prevalent one it is not the only one as shown on Dr. Lyman's sections,* and as may be seen in a field examination.

The deposits were formed in a comparatively narrow lake, bay, or arm of the sea, which was in a general way parallel with the present coast line, and limited by the older rocks on each side. The beds of sandstone and shale were formed by the filling in of a depression not unlike the present great Valley of the Appalachians, which would be an inland sea or bay if the east coast were to be depressed. Part of the materials, the coarse conglomerate, was deposited by rapid streams or currents and part, the shales, in comparatively still water, the sandstones forming an intermediate grade. Whether we consider Dr. Lyman's estimate of 27,000 feet or a greater or less thickness, we see that the greater portion of the whole is composed of shales, a comparatively small part of sandstones, and a still smaller per cent. of conglomerates, but the proportion is by no means uniform. Thus at Portland, Conn., there is a thickness of more than 500 feet of nearly all sandstone with some conglomerate and very little shale. In the vicinity of Mohnsville, Birdsboro, Schaefferstown and Cornwall there is a great deal of conglomerate, some of it very coarse. West of the Susquehanna shales appear to predominate with but little sandstone or conglomerate.

Throughout the entire brownstone area both in this and other states there are considerable areas of trap rock, which occurs intercalated between the layers of sandstone and shale, cutting through them in dikes or covering the surface in boulders, without showing the method of extrusion, and which has been utilized for road material and to some extent for building stone.

*In the Atlas to the summary Final Report, Pa. Geol. Surv., 1893.

A. Detailed Description of the Southwest Part of the New Red Brownstone Area.

Hummelstown, Goldsboro and Vicinity.

Hummelstown. — The Hummelstown brownstone, which is so well and favorably known by most of the architects and builders throughout the country derives its name from the town of Hummelstown, which is located ten miles east of Harrisburg, and one hundred and three miles from Philadelphia, on the Lebanon Valley branch of the Philadelphia & Reading Railway, and is, therefore, within a few hours distance from Philadelphia, New York, Baltimore, Washington and the other principal cities of the east.

Hummelstown is an old settlement, having been laid out by Frederick Hummel in 1762, who named it Fredrickstown, which name was afterwards changed to Hummelstown. It is older as a town than Harrisburg which was not laid out, as a town, by John Harris, until 1784.

The deposits of brown sandstone are found in the hills southeast, south and southwest of the town, and have been used, locally for tombstones and building purposes from about the time of the first settlement. Tombstones, in excellent condition, dating back to the earlier years of 1700 can be found in all of the old burial places in the vicinity. Many of the old houses and barns are built of the same stone.

The Hummelstown brownstone, as it is the most extensively quarried and best known brownstone of the State, deserves more than a passing notice. It is in fact the only native brownstone that is widely known outside of the State. Stone from other localities has been shipped out of the State, but in small quantities compared with that which comes from the Hummelstown quarries. As the stone varies somewhat in the different openings, different varieties will be described under the heading of the company that owns the quarry.

There are a dozen openings from which considerable stone has been taken. Four of these are worked by the Hummelstown Brown-Stone Company, one was operated by the Pennsylvania Brownstone Company, one by the Middletown and Hummelstown Company, one by Hartlieb Brothers, of Lebanon, one by Francis Painter and Company, of Derry Church, one by the Stoverdale Brownstone Company, one by the Co-operative Brownstone Company, two by the American Brownstone Company, one by Mr. Hummel. Besides those enumerated there are smaller openings of purely local importance.

Hummelstown Brown-Stone Company — While nine different companies have operated quarries in recent years in the

VIEW IN QUARRY NO. 1, HUMMELSTOWN BROWN-STONE COMPANY.
Showing dip of strata and method of working.

RESIDENCE OF SENATOR SAWYER, WASHINGTON, D. C.
Showing use of Hummelstown brownstone in private residences.

vicinity of Hummelstown, the only one in operation at present is the Hummelstown Brown-Stone Company. This is due partly to the more favorable location of their quarries, with reference to the quantity of good stone obtainable, their shipping facilities, the amount of capital invested, and in no small degree to the business tact, energy, and perseverance of the managers which enable them to continue in successful operation during a business depression like that of the present. Believing that they had a good stone which was needed in the market, they gave their time and energy to pushing it into prominence, enlarging their facilities when necessary to meet the demand.

Probably the first regular quarry opened in the region was one, now belonging to this company, located on what was known as the Berst property. A farm house near the quarry built entirely of this stone was erected in 1800. The corner stone bearing the date shows the tool marks as perfectly as when first dressed. (See Plate 2 p. 22.) Stone was quarried on this property to enlarge the locks on the Union Canal in 1853-58. It was also used for bridges and culverts on the Lebanon Valley Railroad, built about the same time.

In all probability it was the quarrying of the stone for this work which first called the attention of stonecutters and contractors from a distance to its value as a building stone, for after this time (1858) there was a continuous trade in stone from this locality, and building stone such as steps, door and window sills were shipped either by canal or rail, to all the larger towns in the adjacent counties.

The quarries of the Hummelstown Brown-Stone Company on the Berst property, were worked in 1860 by Henry Brown, of Harrisburg, who began by taking out stone for the Dauphin County Court-House at Harrisburg. He continued the work by shipping stone to various places, and formed a company under the name of the Pennsylvania Brown Freestone Company, who in 1866 built the first stone saw-mill in this locality. In the fall of 1867 the management of this company was taken by Allen Walton, an enterprising and energetic business man from Philadephia, who immediately set about to extend the business and increase the trade. In 1868 he introduced the stone in the Philadelphia market, and about the same time in Baltimore, Md., yearly increasing the output, which went to Philadelphia, Baltimore and all the larger towns in Pennsylvania.*

The panic of 1873 adversely affected the business, after which time, some of the stockholders were not disposed to invest and en-

*Dr. Julien in a paper before the New York Academy of Science in 1883 (page 222 trans.), says: "In addition to the varieties of brownstone already described there is one quite recently introduced into this city (New York) from Hummelstown, Pennsylvania, in a building on Fifth Avenue, above Forty-first street. It has been largely used in Philadelphia and is said to resist the weather well.

large the plant and increase the business, as others thought should be done; so, in 1877 Allen Walton and Philip Dougherty, who jointly owned about one-half the stock, purchased at sale the entire plant, real and personal, operating the quarries under the name of the Hummelstown Brown-Stone Company, and set about further to extend the business. They furnished the stone used in the new building erected by the Government for the Bureau of Printing and Engraving, and a number of other buildings in Washington, D. C. In the same year a market was opened in Richmond, Va. In 1881 Allen Walton purchased Mr. Dougherty's interest in the quarries and individually continued to operate them under the name of Hummelstown Brown-Stone Company, selling stone in the New York market in 1882, Cleveland, O., in 1883, Chicago, Ill., in 1885, St. Louis, Mo., in 1886, Indianapolis, Ind., in 1887, and Orlando, Fla., in 1888, thus largely extending the trade and giving the stone a wide reputation. In 1886 he built a railroad four miles, connecting the quarries with the Philadelphia and Reading Railroad at Brownstone Station, on that line, and in the same year built a saw-mill at the quarries, abandoning the old mill which was located at Hummelstown. In 1891 he deemed it advisable to incorporate the Hummelstown Brown-Stone Company and to separate it from the railroad, and incorporate that as the Brownstone and Middletown Railroad, of both of which companies he is the president. The active management of the stone business is now largely in the hands of his two sons, although the elder Mr. Walton remains president of the company. The several quarries are equipped with thirty steam derricks, one heavy capacity steam shovel, three steam cable hoists, and a complete line of steam drills, quarry bars and other quarrying tools. The mill and stone dressing shops are extensive, containing 13 gangs of saws, 14 stone planers and stone lathes. The hoisting about the mill and shop is done by two heavy capacity steam traveling cranes, running back and forth on trestle work. From 500 to 700 men are employed at times, the number increasing with increased orders.

The plant further consists of machine, carpenter and blacksmith shops, all fitted out with a full line of tools and machines.

The railroad consists of a line, as before stated, with extensive sidings at Brownstone and at the quarries and is equipped with four locomotives, three passenger coaches and thirty-four cars, used principally for transferring stone from the quarries to the mills and shops.

The capacity of the quarries is practically unlimited, having always been able to meet every demand, and being able to supply any size or quantity of stone ordered, one reason for the increased trade being the promptness and certainty with which all orders are *filled, which means a* great deal with contractors.

Entrance to Engineering Building, State College, Pa. Showing the use of Hummelstown brownstone in doorways.

Structure of the Hummelstown stone. — The strata in and about the quarries all dip about 40 to 45 degrees to the north, thus giving the strike or the line of out-crop an east-west direction. The separate layers vary from 20 inches to 20 feet or more in thickness. While the bedding planes are not abundant, and where they do occur are not conspicuous open seams, yet there is throughout the bed an easy cleavage parallel with the bedding on which the layers can be readily split into any thickness desired. These seams are more abundant near the out-crop and least so in the bottom of the quarry. The joint seams in these quarries are not numerous and not very regular. There are are a few incipient cracks due to the bending or folding of the strata.

The total thickness of the stone is not known. Including the conglomerate, sandstone and the shales there is certainly not less than several hundred, probably several thousand feet. The greatest thickness of good quality of brownstone at one place is about 50 feet, as shown in nearly all the quarries of this company. But while this 50 feet is immediately underlain and overlain by red shale and conglomerate good stone is known to occur, both above and below the bed quarried. In fact, one of the quarries is in layers that underlie those in the other quarries, and the Pennsylvania Brownstone quarry to the north is in overlying layers with out-crop of good stone between. Thus the supply of good stone is practically unlimited. The only question is the economic production of it, which question the company has answered successfully so far.

There is a possibility, of course, of east-west faults causing a repetition of the same layers in successive out-crops, but there is no evidence in favor of this theory, not even in the character of the rocks in different places.

Texture of the Hummelstown stone. — The stone varies somewhat in texture, there being fissile red shale, fine grained sandstone and both shale and quartz conglomerate, but there is not such an intermingling or gradation of these one into another as is noticeable in some brownstone regions. The series alternate but rarely mix, except in some places where there is a mingling of the shale fragments with the sandstone. There are heavy layers of coarse quartz pebbles in the series, but the little patches or thin bands of pebbles running through the good stone as observed in some localities do not occur here. The first-class stone is an even fine grained stone, remarkably uniform both in texture and color, probably unsurpassed in this property by any brownstone in the United States, certainly not by any that occurs in similar large quantities, so far as observed by the writer. One of the greatest defects in the majority of brownstone deposits is the lack of uniformity in either color or texture or both.

The texture of the Hummelstown stone is close, the grain fine, and it will take a very smooth finish. While the actual absorption of the stone is not much below the average, the pores are small and the dressed surface smooth.

Color.—There are two decided shades of color in the stone from the different quarries. The most abundant shade and one that comes from all but one of the quarries is a reddish brown, a brighter, warmer shade than the average New England stone, but not so bright as one variety of the Michigan (Portage Entry) stone or the English red stone, more nearly resembling the East Longmeadow (Massachusetts) stone in color than any other now in mind. It is among the darkest colored ones in this State, those further east being almost all lighter colored, except that at Mohnsville and Frog Hollow. The other shade of the Hummelstown stone, a purplish brown, which comes from their quarry No. 3, harmonizes very well with the redder tint and buildings with the lower part of the purple stone and the upper part of the red stone, present a very nice appearance. In fact, either shade would make a nice trimming for the other.

Composition.—The two analyses given below show the chemical composition of the stone. The first one was made in the chemical laboratory at State College, the second in the chemical laboratory of the United States Geological Survey.

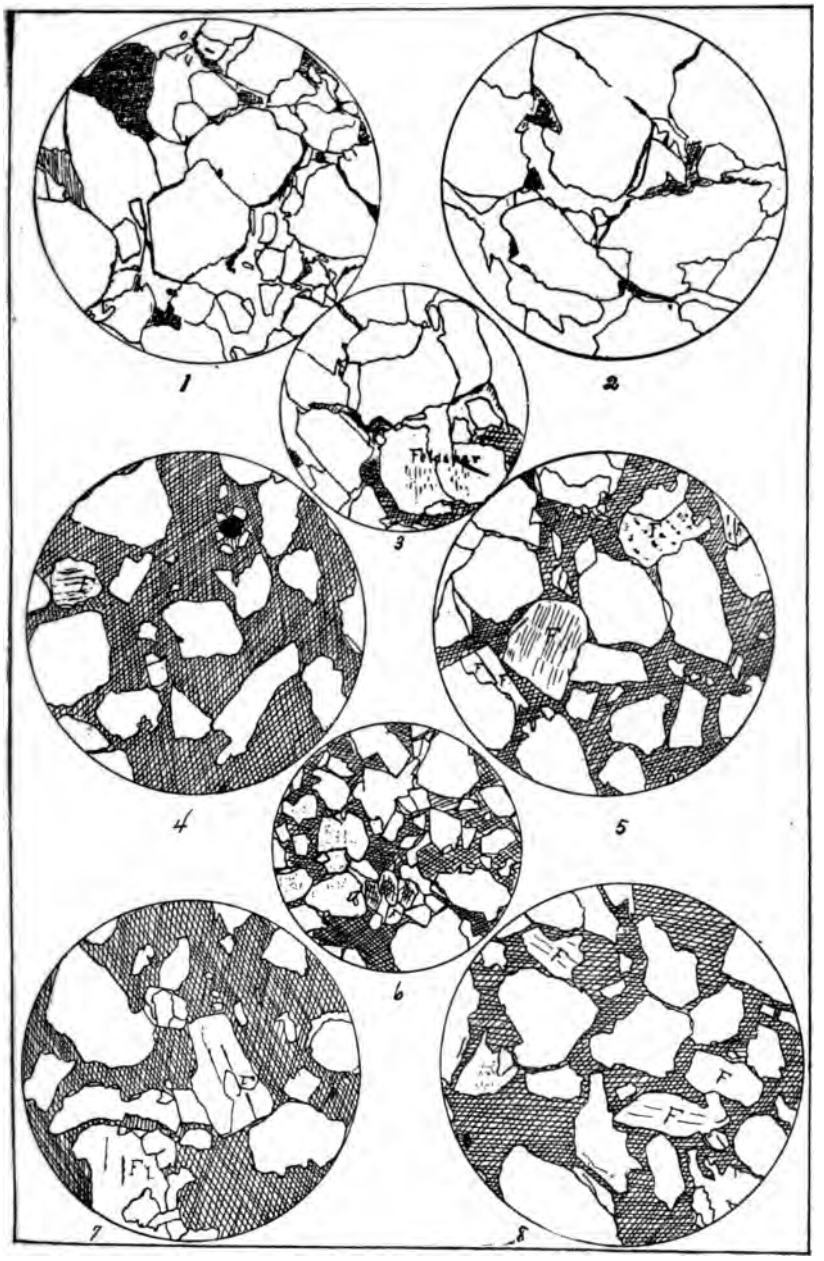
Chemical analyses of Hummelstown Brownstone.

	1 Per cent.	2 Per cent.
Silica (SiO_2),	90.341	88.13
Alumina (Al_2O_3),	4.350	5.81
Ferric Oxide (Fe_2O_3),	1.093	1.77
Ferrous Oxide (FeO),	.749	.31
Lime (CaO),	.953	.20
Magnesia (MgO),	.167	.53
Soda (Na_2O),	.188	.06
Potash K_2O),	1.299	2.63
Water,	.612	.49
Total,	99.744	99.93

Microscopical character of the Hummelstown stone.—The microscope shows it to be a stone made up largely of small angular (for the most part) quartz grains and numerous angular to subangular grains of feldspar in a cement of clay and iron oxide. The feldspar is much decayed and less abundant than in the stones farther east in the State or in the more eastern States. The grains appear to be pretty regularly diffused through the cement, with no pronounced lamination of the coarser and finer grains into separate layers or directing the longest diameters of the grains in the same di-

The mill and some of the quarries of the Hummelstown Brownstone Co. Showing the [illegible]

Brownstones of Pennsylvania. **Plate X.**



Microscopic sections of Hummelstown brownstone, magnified 44 diameters.
F signifies feldspar; cross-lined areas aggregates of clay, fine quartz, and iron oxide; mostly clay; very dark shading iron oxide; colorless areas quartz.
No. 1—Pennsylvania Brownstone Co.'s quarry.
No. 2—Swatara quarry hard quartzose sandstone.
No.'s 4, 5, 7, and 8 Hummelstown Brownstone Co.'s quarry.
No. 3—An enlarged portion of a quartzose area from another part of No. 5.
No. 6—A less magnified portion, showing a larger area of No. 5.

rection, thus giving the stone a freestone rather than a flagstone character. The cement consists of clay mixed with iron oxide, the iron oxide appearing to be segregated in only a few places and there in but small particles. It is for the most part diffused through the clay in a very finely divided state and partially coating the grains in very thin pellicle. This would indicate that the iron was deposited simultaneously with the sand and clay, and that it has been modified very little since that time.

The figures on the accompanying plate (Plate X) are traced from the different parts of the sections viewed in the microscope (see also Nos. 4, 5 and 6 on Plate 1.) No. 6 is magnified 20 diameters, the others 44 diameters, drawn double the size and reduced. No. 3 is an exceptionally quartzose spot, looking almost as if there had been secondary quartz deposited among the grains. However, it may be but a shattered piece of quartz or a fragment of quartzite a little larger than the one shown on Plate 1.

Crushing tests of the Hummelstown brownstone from the quarries of the Hummelstown Brown-Stone Co.

Number.	Area, square inches.	First crack, pounds.	Total crushing strength, pounds.	Crushing strength, pounds per square inch.	Authority.
1	6.92	101,000	116,600	16,850	U. S. Government, Watertown Arsenal, 1897.
2	6.92	56,000	88,700	12,818	U. S. Government, Watertown Arsenal, 1897.
3	6.73	74,000	98,200	14,597	U. S. Government, Watertown Arsenal, 1897.
				14,753	Average of the Watertown tests.
4	7.13	103,600	104,236	14,619	Rose Polytech. Inst., Terre Haute, Ind., 1897.
5	6.94	101,800	102,447	14,761	Rose Polytech. Inst., Terre Haute, Ind., 1897.
6	7.25	91,334	94,528	12,580	Rose Polytech. Inst., Terre Haute, Ind., 1897.
				14,000	Average Terre Haute tests.
7	6.80	.....	100,240	14,740	Riehle Bros., Philadelphia, Pa., 1897.
8	6.80	.....	93,840	13,800	Riehle Bros., Philadelphia, Pa., 1897.
9	6.80	.....	96,050	14,120	Riehle Bros., Philadelphia, Pa., 1897.
10	6.80	.....	100,500	14,780	Riehle Bros., Philadelphia, Pa., 1897.
				14,360	Average Riehle Bros. tests of quarry No. 3 stone.
11	7.04	.....	70,660	10,090	Riehle Bros., Philadelphia, Pa., 1897.
12	7.04	.....	87,100	12,440	Riehle Bros., Philadelphia, Pa., 1897.
13	7.04	.....	79,040	11,290	Riehle Bros., Philadelphia, Pa., 1897.
14	7.04	.....	71,100	10,160	Riehle Bros., Philadelphia, Pa., 1897.
				11,100	Average Riehle Bros. tests, quarry No. 4.
15	9.375	.....	122,000	13,010	Riehle Bros., Philadelphia, Pa., 1890.
16	9.178	.....	122,000	13,290	Riehle Bros., Philadelphia, Pa., 1890.
17	9.375	.....	121,800	12,990	Riehle Bros., Philadelphia, Pa., 1890.
				13,100	Average Riehle Bros. tests, 1890.
				13,460	Average of all the tests on the Hummelstown stone.
				14,370	Average of all the tests on the Hummelstown stone, quarry No. 3.

The crushing strength of the Hummelstown stone, as shown on the accompanying table, is above the average for sandstones, standing intermediate between the common sandstone and the quartzite.

Bullitt Building, Philadelphia, Pa.

Residence of Mr. Ellis, Broad Street, Philadelphia, Pa.

Showing use of Hummelstown brownstone in business blocks and private residences.

In a list of tests on 62 specimens of the best known sandstones of the United States, including brownstones, given by General Gillmore in 1875,* there are 17 with a strength below 6,000; 43 below 9,000 and 49 below 10,000 pounds per square inch.

The specific gravity as determined in the laboratory at State College is 2.66, equivalent to a weight of 166.1 pounds per cubic foot. The specific gravity as given by Julien† is 2.35, equal to 146 pounds per cubic foot. A carefully dressed six-inch cube of the purple stone weighed 18 1-4 pounds, equal to 146 pounds per foot, which is practically the weight of the seasoned stone as it goes into the wall. A cube of the red-brown stone showed 150 pounds per cubic foot, which is the weight used by the company.

Durability.—There are several reasons for thinking that the Hummelstown brownstone is one of the most durable brownstones on the market. Both the chemical and mineralogical composition leave little to be desired in that line. The rock is composed of fine angular quartz grains with a very little undecomposed feldspar in a cement of clay and iron oxide. The relatively small quantity of the feldspar is shown both by direct examination in the microscope and by inference from the chemical analyses indicated by the small percentage of alkalies and lime (see p. 13). Clay, one of the chief residues from the decaying feldspar, in itself is one of the most durable of substances, but if present in large quantities in a rock with other constituents, is a source of disintegration by its property of absorbing water, which freezes and crumbles the rock. This is worse where the clay is segregated in patches and layers. Outside of this property it makes one of the best cements for sandstone, especially when mixed with iron oxide, because it binds the grains with sufficient firmness to make a strong rock, and yet not so firmly as to make it difficult to cut, saw, or break. The quartz cement is the most durable of all, but it makes the rock too hard for tool work. Lime cement is likewise too hard. So the only theoretical improvement that could be made in the chemical composition of the Hummelstown stone would be to have all of the feldspar changed to clay with the removal of all the alkalies and possibly a part of the clay. Yet the clay could not be decreased to any considerable extent without making the stone friable unless there was something else substituted.

With the exception of the natural outcrops, I have never seen any disintegration, scaling, or cracking of the Hummelstown stone, nor has inquiry among architects or stone dealers revealed any. As the quarries are not so old as the more eastern ones, it is difficult to make a comparison with them in this respect. The conditions, however, are these, that there are a great many brownstone fronts

*Appendix to Annual Report, Chief of Eng., U. S. A., 1875.
Trans. N. Y. Acad. of Sci., April 1--30, 1883.

in Philadelphia, New York and other eastern cities built of eastern brownstone which are disintegrating and scaling badly, most conspicuously so in the porches and courses next to the ground. So far as known to the writer there are none such of the Hummelstown stone. However, investigation has not been thorough enough on this line to say that there are none, nor to say that of those that are disintegrating none was built of stone which had been quarried since the Hummelstown quarries have been opened. It is not intended to state that all of the Hummelstown stone that has ever been used remains firm and uninjured, but simply to state that none of it observed or found on inquiry by the writer was scaling or disintegrating. Nevertheless, the evidence in this line combined with a comparison of the texture and composition is sufficient to guarantee the assertion that the Hummelstown stone is more durable than most of that used in brownstone fronts in New York, and that none of the other brownstones in the market of this country, so far as known to the writer, that are as easily worked as the Hummelstown stone are any more durable.

It is stated that the Hummelstown stone when first introduced into the Philadelphia market in 1868 was used by the architects principally for the base-courses of buildings built of New England brownstone. They at that time thought it was too hard to dress for trimmings or face work, but could be used for base-courses, as they supposed it to be more durable than the eastern brownstone, which was even then crumbling badly.

The 10th census report,* commenting on this stone, says: "The Hummelstown brownstone, the hardest and most compact of all these brownstones, has been introduced here (Philadelphia) within the last fifteen years, and is used principally for trimmings in buildings of other stones and in brick buildings, giving a very pleasing effect. This stone as yet shows no evidence of disintegration in any of the buildings in which it has been used, and has the reputation here of being quite substantial and durable."

Inquiries were made of a number of leading architects in different cities and those that replied without exception spoke highly of the durability of the Hummelstown stone.

The oldest building known to be constructed of the Hummelstown stone is a farm building, the Berst house, near the quarry, erected in 1800, in which the stone shows no sign of decay nor discoloration, but is apparently as strong and bright as when first laid. (See plate 2.) Another building nearly as old was observed at Hockersville, and there are no doubt others in the vicinity.

The Quarries.—The company is now operating at three different points, not widely separated, known by numbers as Quarry No. 1, No. 3 and No. 4. The No. 2 opening has been abandoned, as have

*Tenth Census, 1880, Vol. X, Building Stone, page 343.

Library, Mount Holly, Pa.

Westminster Presbyterian Church, Harrisburg, Pa. Showing the use of Hummelstown brownstone in public buildings.

Governor's Mansion, Harrisburg, Pa. Showing use of Hummelstown brown-stone in fronts.

several smaller openings on the hill north of No. 2. Quarries No. 1 and No. 3 are on the same ledge of rocks, and while at one time they were separate openings, intervening material has been worked out, and they now form one opening about 250 yards long and said to be 165 feet deep at the deepest point, No. 1 at the west end and No. 3 at the east end. The company does not contemplate any deeper workings at present, but are extending it laterally by working at each end.

The strata dip 40 to 45 degrees to the north, thus the strike along which the quarry opening extends runs nearly due east and west. As the opening is on the south side of the hill, the thickness of the over-burden increases rapidly with the depth of the quarry.

The stone, which is about fifty feet thick, is overlain by a heavy bed of red shale, mixed with conglomerate and streaks of sandstone. In some places it is underlain with red shale or a shaly sandstone, in some places by a soft conglomerate and in one place near the middle of the quarry an opening has been made through two or three feet of this conglomerate into 10 feet or more of good brownstone. The possibilities in this direction are inviting. The valuable stone in quarry No. 4 is taken from ledges that underlie those in Nos. 1 and 3. There are evidences of good stone still lower, and there is certainly good stone overlying the layers in the quarry, so that the bed worked in the quarry (Nos. 1 and 3) is but one of a series. As the strata change in character from point to point, it is impossible to tell with certainty what will be the economic character of the layers at any point until they are examined. So that the company, after exhausting the deposits at the present quarries, may find good stone in the under-lying layers so close that it might be worked more cheaply from the present quarry floor, than from a new opening.

The upper part of the accompanying plate (Plate VI) is a view taken in quarry No. 1, showing the disposition of the strata and the shape of the opening, the character of the overlying material and the bedding and jointing of the rock.

Quarry No. 4 is in active operation at present. It lies about 200 yards southwest of No. 1 in a lower series of strata, and on the opposite side of the valley, as there is a small lateral ravine from the southeast at this point, it is on the northeast point of the ridge. There is about the same amount of stripping as in quarry No. 1, but the overlying material differs in character, consisting almost entirely of conglomerate and sandstone, with very little shale. There is

about the same thickness of good stone exposed as in the other quarries, with a better prospect of good stone underneath the quarry floor. The accompanying figure (Fig. 2) is a general sketch across

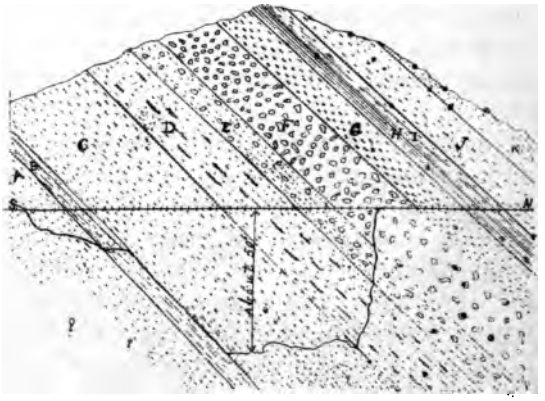


Fig. 2.—Vertical section across quarry No. 4. A, good brownstone thickness not known; B, shaly brownstone; C, good quality red-brown stone; D, second and third quality stone contains soft spots; E, pebbly sandstone; F, coarse conglomerate; G, uniform sandstone; H, I, red shale and shaly sandstone; J, brownstone weathered; K, brownstone much disintegrated. N--S railroad.

the west face of the quarry It shows the character of the rock exposed, the angle of inclination of the strata and the size and shape of the quarry opening. The railway track runs at the level of the black line connecting with the other tracks and the dump.

The methods of quarrying are adapted to the position and character of the stone. As may be seen from the position of the strata, the channeling machine could not be used to advantage. The steam drill and quarry bar are used with the Knox blasting system to loosen the stone in the quarry. It is then lifted by a steam hoist on one of the numerous large derricks or on one of the large wire cableways to the car, where it is transferred to the yard for scabbling or to the mill to be sawed, planed, or turned into the desired form. The stripping and waste of the quarry are loaded into large dirt boxes and lifted by derrick or cableway to the cars on the railway track and thence transported to the dump pile. Where the stripping consists of loose material its removal is facilitated by the use of a large steam shovel. The company has spared no expense in equipping the quarry with the most modern machinery for the rapid quarrying and handling of the stone.

The stone after it is prepared for the market is loaded aboard the railway car at the mill or the yard, the fine cut stone being packed in shavings, and transferred by the company's engine over their own track to the Philadelphia and Reading Railway at Brownstone sta-

tion.

One can appreciate the growth of the stone industry at Waltonville by observing the forest of derricks, the numerous railway tracks to the different openings and different parts of the yards, the well equipped mill with its many workmen and mass of machinery, the locomotives moving about the yards, the clatter of the steam drills, the creaking of the steam hoists and the multitude of workmen scattered about the premises and then look at the old road wagon rapidly crumbling to pieces near Brownstone station and hear that all the stone shipped from Waltonville was at one time hauled on this old wagon.

The stone has been used in nearly all the large cities of eastern and central United States, and in many of the smaller ones. Philadelphia, New York, Washington and Baltimore are the largest markets. The stone has been used in some of the finest buildings in Washington. It has also been used extensively for bridges, piers and abutments. It is adapted to buildings of all kinds, and may be used alone or in combination with brick or other building stone. Some of its varied uses and its adaptability in architecture are shown in the accompanying illustrations, which show a few of the many buildings in which the stone is used. A list of the more important buildings constructed wholly or in part of this stone is contained in the general list on pages 39 to 44.

The Pennsylvania Brownstone quarry.—The Pa. Brownstone Co., Limited, was incorporated in the fall of 1886 by Samuel Fox, Wm. C. Erb and Edwin B. Erb, who leased property and opened a quarry on the north side of the hill, about two miles south of Hummelstown, the nearest railway point, and half a mile or more north of Waltonville. They built a stone mill at Hummelstown and invested a large sum of money in developing the quarry, and while considerable stone was shipped, the business proved unprofitable, possibly because of the large quantity of waste material to be handled and the long haul to the railway. In the fall of 1890 they sold their mill, quarry equipment, and lease to the Hummelstown Brown-Stone Co., who later purchased the land. It has not been worked since that time.

This quarry is near the north limit of the brownstone belt, and the strata still have the northerly dip as in the other quarries. Yet it varies to some extent from that in the quarries further south, the dip being not so steep and inclining more to the west, 25 to 35 degrees N., 20 degrees W., but not uniform. The thickness of the brownstone in the opening is about 50 feet and the opening is 80 feet or more in depth and about 60x100 yards in area. The stone is badly weathered to a depth of 20 or 25 feet, and contains many irregular seams throughout the greater part of the bed. The rock occurs in regular beds 10 to 20 feet thick, but the presence of the seams

or cracks in different directions through the rock causes considerable waste in quarrying the stone into rectangular blocks for dimension stone. Occasionally thin streaks of brown shale occur between the layers, and there is a little cross-bedding and ripple marks in places. The microscope shows it to be made up of sharply angular quartz grains, with chert fragments and an admixture of clay and iron oxides. There is a greater proportion of iron oxide and less of the clay than that examined from the quarries further south.

The quarry being on the north side of the hill, with the north dip to the rocks, there is not the constantly increasing thickness of the overlying material as in the quarries on the south side of the hill. However, the rock is more fractured and apparently weathered deeper than on the south side. Unless there is good stone underlying that exposed in the quarry it is questionable if first-class brownstone could be quarried as economically here as in the quarries on the south side of the hill.

Light colored brownstone of good quality outcrops in the soil in various places on the hill between the Pennsylvania quarry and the Hummelstown Brown-Stone Co.'s quarries, and future investigation may develop extensive quarries in this locality.

The Co-operative Brownstone Co. has made a small opening about one-half mile northeast of the mill of the Hummelstown Brown-Stone Co., in which there is a nice light reddish brownstone exposed, but the opening is too small (20-25 feet deep) to show anything about the quantity of good stone. So far as it is opened the stone is in small dimensions, being much broken by numerous irregular seams and much disintegrated near the surface. So far as known to the writer, no stone has been shipped from this opening. It is not in operation at present (1896).

The Stoverdale Brownstone Co. in the fall of 1895 made a small opening alongside the public road about one-half mile south of west of the Hummelstown Brown-Stone Co.'s quarry No. 4. The work ceased after a small quantity of the stone was shipped. The opening is not large enough to show how extensive the deposit of good stone may be. The strata dip 47 degrees N. 15 degrees W. in one place, but the dip is not uniform. There is a thickness of 10 feet of fairly bright colored brownstone overlain by several inches of brown shale followed by weathered brownstone shelly and full of seams. Underlying the 10 feet of good stone is other brownstone shelly and seamy so far as exposed. At a greater depth these weathered seams are liable to disappear, at least in part, and the stone become more solid, but whether the quality would be first grade and whether it could be removed with profit could only be determined by further investigation.

There are a number of old openings along the hill southeast of the Stoverdale quarry said to have been made by a Mr. Martin many

Market and Fulton National Bank, New York City.

Enlarged view of the doorway of the same.

Base, entrance and trimmings of Hummelstown brownstone.

years ago. Brownstone is exposed in all of these openings, but it is all badly weathered, none of the openings showing a sound stone of value, yet some of them indicating a possibility of obtaining good stone at a greater depth.

About a mile south of the Stoverdale quarry is an opening known as the *Hummel Quarry* which shows about 16 feet of brownstone of a pleasing color and nice, even texture, but so far as opened, containing numerous seams so that much of the stone would be in small dimensions. It could not be ascertained when this quarry was operated or how much stone was removed. But it has not been operated for a number of years, and it is said the principal reason for abandonment was the great number of seams.

There is a smaller opening a short distance west of the main opening in a mass of large boulders of fine looking brownstone.

American Brownstone Company.—A few hundred yards southwest of the Hummel quarry are two openings known as the Warner quarry and the Rupp quarry, which were opened by Jones and Collins, under the name of the American Brownstone Company, about the spring of 1890, and worked at intervals during the two or three years following that date since which time they have been idle.

The thickness of the good stone in the Warner quarry is apparently about 20 feet, but as it is inclined at a high angle, both the underlying soft conglomerate and the overlying shelly and shaly sandstone have crumbled and rolled down over the good stone and the bottom of the hole is covered with water concealing the greater part of it. The part exposed shows a stone of nice color and texture.

In the John Rupp quarry while the angle of the dip is but little different from the other quarries in the vicinity the direction of dip is markedly different, being nearly west (S 85 degrees W). In the Hummelstown Brown-Stone Co.'s quarries the dip is nearly north, in all the others it is a few degrees west of north, but in no other does it vary so much from north as in this quarry. The best stone appears to be in the bottom of the quarry, the lower 8 to 10 feet, the 15 to 20 feet overlying containing many seams. A small opening about fifty yards from the large opening shows a better quality of stone, but only a small quantity exposed.

The Middletown and Hummelstown Company opened a quarry on the Middletown and Hummelstown railway, about one and one-half miles northeast of Middletown. The quarry was well equipped with modern machinery, having a switch from the railway into the quarry, five large derricks and one small one, with steam hoists, and a mill equipped with two saw gangs. There is an electric plant which is said to have been put in after the quarry was abandoned. The quarry has not been in operation for a year or more, but particulars could not be obtained as to when it was opened, or how long it was

in operation, the amount of stone produced, where shipped, etc., in fact nothing but what could be obtained by a visit to the place and observing the empty quarry and the crumbling machinery.

The strata dip 25 to 30 degrees N. 60 degrees W. with the quarry opening on the southwest point of the hill, the stone thus dipping into the end of a steep hill. There is a thickness of about 20 feet of quarry stone underlain by a soft, shaly sandstone and overlain by a heavy bed of conglomerate, a mixture of quartz and shale conglomerate. This conglomerate is about 40 feet thick on the present quarry face and would thicken very rapidly on deeper quarrying. The stone in this quarry is softer than any of the other stone in this vicinity, many of the fragments lying about the mill and quarry being so soft as to be crumbled and broken in the hand. There are numerous spots of iron rust that give the stone a faint spotted appearance and appear to be one cause of the crumbling as the iron appears to be undergoing some chemical change.

The Erb quarry.—About two miles south of Swatara station Mr. Erb has made a small quarry opening on the northwest slope of the hill, where the strata dip about 32 degrees N. 65 degrees W. The stone has a nice, purplish color, even grain and texture, but is hard and brittle ("flinty") and contains many cracks and seams, particularly near the surface. At the bottom of the opening, probably 20 feet from the surface the seams are fewer in number, yet still abundant, and the rock continues brittle or " plucky." See plate X No. 1 for microscopic view of this stone, illustrating its hard or plucky nature in which it will be seen in comparison with the Hummelstown stone that the quartz grains are more numerous, closely compacted, with very little cement. That it is difficult to break can be inferred from a glance in which one can see that a fracture in the rock must break a considerable number of quartz grains and pull others from a closely felted mass of its fellows while in a free stone only the cement is broken, the grains pulling free from the cement on one side or other of the break.

The nature of the stone and the difficulty in getting the large dimensions will probably prevent the extensive production of stone at this point.

The *Swatara* quarry was opened by the Hartlieb Bros. of Lebanon, in the spring of 1894 and small quantities of stone have been shipped from there at intervals since that time. The quarry is a mile or a little more west of south from Hockersville and near the north limit of the brownstone belt. It is about 250 yards south of one of the large iron ore mines in the Trenton limestone that was worked extensively several years ago.

The strata are disturbed more or less so that the dip is not uniform, but in general it dips to the west and the north of west, in one

Arcade Building, Cleveland, O., and enlarged view of the entrance.
Entrance, piers and trimmings of Hummelstown brownstone.

place northwest 40 degrees. There is about 25 feet of solid, rather uniform brownstone, but it contains numerous seams. It is overlain by three feet of shale and soft sandstone, followed by 10 to 15 feet of sandstone and shaly conglomerate, followed in turn by much weathered brownstone that may prove to be good stone at greater depths. The quarry is not in operation this year (1896). Whether permanently or only temporarily abandoned is not known, letters of inquiry to the company eliciting no response.

The Derry quarry about two and one-half miles southeast of Hockersville was opened by Francis, Painter & Co., of Derry church, in the fall of 1884, and operated by them for four years, until the fall of 1888, when they disposed of their equipment and abandoned the quarry. The quarry has not been operated since 1888. The strata dip about 20 degrees N. 65 degrees W. and are quite regular with even bedding surface. The best stone, a beautiful fine grained brownstone, is about 16 feet thick, and is overlain by a brown shale and sandstone, some of which furnishes good stone. The quarry was fairly well equipped and worked rather extensively during the few years it was in operation, making an opening about 80 to 100 yards long and 40 yards wide at the top and 50 to 60 feet deep. The quarry has been cut down at one side so that the carts can go in to haul out stone. The other side has a nearly perpendicular face. The stone does not differ greatly from the other quarries in the region, being a little lighter in color, apparently more brittle, and having more seams.

The stone from this quarry was hauled to the Philadelphia and Reading R. R., a distance of about three miles, part of the way over exceedingly rough roads, which would certainly make a sad inroad into the profits on the stone. No particulars could be obtained regarding the markets, uses, etc., of the stone from this quarry, further than the statement that considerable stone was removed and shipped to Philadelphia, Baltimore, York, Lebanon, Harrisburg, and other points.

Brownstones of different shades outcrop in many places in the vicinity of these different quarry openings, some of which no doubt is of good quality and in which good quarries might be developed. However, as shown by the numerous failures in the way of abandoned quarries in the region, the work is attended with much risk, and one might make a dozen openings before striking a deposit of good stone of sufficient thickness and quality to be quarried with profit. Much of the money spent in the different openings has been squandered for the want of a little elementary knowledge of geology. It is a pure waste of money and time to follow a layer of conglomerate, or shale, or micaceous stone into the hill, expecting it to change to good stone. While there is a possibility that it may lose

some of its conglomerate character or that it may become less shaly with depth, the chances are equally as good for its becoming more conglomeratic or more shaly and the possibility of an entire change of character to very good stone within the limits of a quarry face is not one in a hundred. The only changes for improvement in the quality of the stone with depth that is reasonable to expect are fewer seams and less disintegration. The exposure of the stone at the surface allows the weathering agencies to open the incipient seams and some of the constituents to crumble, but the fragments of rock left in the soil will not be much unlike the rock at greater depth. Hence it is pure waste of money to make an extensive quarry opening in this or any other region without first making a careful examination of the surface conditions. Even then the risk is great enough, owing to the local changes in the character of the rock.

Goldsboro (Reehling) quarry.—So far as commercially developed, the part of the New Red formation west of the Susquehanna river is one of the least productive parts of this area in the State. The red shales and sandstones occur in a broad area, extending southwest through Adams and York counties, but so far as known the only quarry from which any stone has been shipped is the one near Goldsboro described below, and no others of any considerable local value could be found by inquiry in a hasty trip into the region. There was no opportunity for a personal investigation of undeveloped areas.

There is a large brownstone quarry on the Reehling farm about two and one-half miles west of Goldsboro, York county, that was opened in 1851 by Thomas Symington, of Baltimore, Maryland, and operated by him until 1856, when the property was purchased by George Betz, of Ashland county, Ohio. Mr. Betz operated the quarry for a few years, and J. H. Killwell followed him for a short time. August 20th, 1869, the quarry was leased by Frazer & Reehling, who were succeeded in the next April by the late C. F. Reehling, who operated the quarry continuously until 1880, when it was leased by the Hummelstown Brown-Stone Company, and has been idle since that date.

The nearest railway point to the quarry is Goldsboro, a station on the Northern Central railroad, on the west bank of the Susquehanna river, about ten miles below Harrisburg, and two and one-half miles distant from the quarry.

The cost of transportation by wagon from the quarry to the railroad was seven cents per cubic foot. The average annual output of the quarry from 1869 to 1880 is said to have been between 14,000 and 15,000 cubic feet, valued at that time at about $15,000.

The stone was used for base-courses, steps, sills and other trimmings in buildings in many of the towns along the Northern Central railroad between Baltimore and Williamsport, and on the Cumber-

Pottier and Stymus Building, New York City.

Showing the use of Hummelstown brownstone in brownstone fronts. (Entire front of dressed brownstone.)

l Valley railroad from Harrisburg to Hagerstown. It was also l for bridge abutments, and to a limited extent for monumental poses.

he stone has been removed from two quarry openings, one on each s of a shallow ravine from the north, which cuts through the ge of rock nearly at right angles to the strike. In each one of the nings the stone has been worked east and west along the strike the rocks about 100 yards, the openings being 40 to 50 yards oss the top and 50 to 60 feet deep.

he strata are inclined 40 degrees, north 20 degrees west. The ckness of the bed of good stone appears to be about 12 to 15 feet h overlain and underlain by red shale. As may be readily imned with a quarry bed of this thickness, inclined at this high gle, it could not be quarried to any great depth until the stripping uld be too heavy to permit further deepening of the quarry with fit, and it becomes necessary to extend it lengthwise along the ike.

he rock is quite evenly bedded, with an easy bedding cleavage, so t after the stripping is once removed, it can be lifted easily and h little waste. It can thus be quarried profitably to a greater pth than a heavy bed of more refractory stone having numerous egular seams.

he accompanying figure (Fig. 3), giving a section across the west

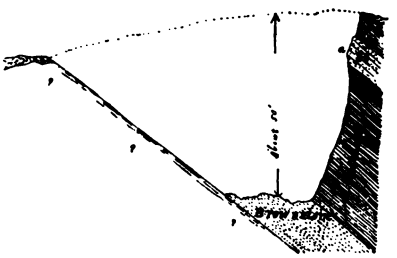


Fig. 2. Section across the Goldsboro brownstone quarry.

l of the opening, shows the position, the nature and thickness of stone, and the shape of the opening. There is no opening to indie the character of the underlying rock. Whether such has been de either by drilling or excavating could not be ascertained. The face is everywhere covered with soil which is quite sandy, with merous fragments of sandstone scattered through it, indicating t at least some sandstone occurs underneath the bed that has n quarried. Whether it is in commercial quantities and of good ality would require further investigation.

he laminated sandstone shown at (a) in the figure, occurring as does on the perpendicular face of the quarry, could not be exam-d except at a distance. It appears to be too shelly or too much

broken at the exposure to be of any use unless perchance for very rough rubble work. It would no doubt improve in quality with the depth, but whether it would become sufficiently valuable to pay for the removal of the overlying shale, thus permitting the under stone to be worked deeper, might justify investigation, although the inducement is not great. The present condition so far as could be observed at the old opening, would rather justify investigation of the underlying beds if such has not already been done.

With the proper transportation facilities at the quarry, large quantities of good stone could be removed with profit at this place at the present price of stone. There is said to be another small quarry three-fourths of a mile north of the Reehling quarry, which was not visited by the writer. It is but a small opening, said to have been worked but very little.

About a half mile southwest from the Reehling quarry is a promising outcrop of brownstone, similar in color and texture to that in the quarry described above, but apparently in heavier layers, so far as can be judged from the boulders covering the surface. Judging from the sandy soil and the distribution of the boulders, there is a thickness of not less than 50 or 60 feet of sandstone, with possibly some intercalary shale and a little conglomerate.

There is an outcrop of brownstone and conglomerate in the village of Goldsboro, but it contains so many pebbles that it is doubtful if any good stone could be obtained. On the east bank of the creek, a half mile west of the village, there are a few thin layers of sandstone in a heavy bed of brown shale. On the west bank of the creek, near the iron bridge, some stone has been quarried for local use. In many places west of Goldsboro sandstone outcrops, and future investigation may show stone in commercial quantities.

Brownstone generally filled with pebbles occurs in many places in York county, but inquiry at different places failed to reveal to the writer any quarries even of local importance. Eli Seifert has quarried some coarse brownstone from surface rocks in the vicinity of Dover, and hauled it to York by wagon, a distance of eleven miles. Mr. Seifert says the stone is coarse and rough, and not fit for fine buildings. It was used for bridge coping and foundations.

B. Detailed Description of the Central Part of the New Red Brownstone Area.

Mt. Gretna, Cornwall, Schaefferstown, Mohnsville, Birdsboro, Phoenixville, Valley Forge, Port Kennedy, Norristown, Fort Washington, Doylestown and Grenoble.

Residence of S. F. Everett, Cleveland, O.

Showing the use of Hummelstown brownstone in private residences.

Mt Gretna.—Near Mt. Gretna station on the Cornwall and Lebanon railroad, Mr. A. G. De Huff, of Lebanon, opened a quarry in the New Red sandstone primarily for the sand. First loose sand from the disintegrating sandstone was screened and used. Later he put up a rock crusher and now crushes the weathered sandstone and screens that. In working this sand quarry he opened up some ledges of nice light brownstone, which has been used for building purposes. The accompanying illustration (Fig. 4) shows the depth of these ledges in the face of the said quarry.

Fig. 4.--Mt. Gretna Quarry

As the primary object in this quarry is sand, the opening has not been carried to any great depth, as the weathered rock crushes most easily. The pit at the crusher has practically no good stone. The one back 100 yards from the crusher shows on the present face:

3—6 feet of soil and sand.
3 feet shelly sandstone
8—10 feet brownstone with a few weather seams.
1—2 feet red shale.
6 feet brownstone with streaks of pebbles.

The bottom of the quarry is in the brownstone. How much deeper it extends at this point is not known.

The brownstone has a uniform reddish brown color, lighter and brighter than the average brownstone. It has a rather sharp, coarse, angular grain, with streaks of pebbles an inch to two or three inches thick, not continuous, but often extending several yards, and in all cases parallel with the bedding, the stone having an easy cleavage in that direction, so that the pebbly streaks can be readily split from the other rock.

The little building stone that has been removed has been used in Lebanon. The weathered shelly stone, spalls, etc., are all taken through the crusher and rolls, ground into sand, screened and

shipped to Lebanon for use in the furnaces and in the building operations. The owner contemplates putting in a washer to wash the sand. The broken quartz pebbles that are not ground to sand between the rollers are screened out and thrown aside. These pieces, which are light colored and about the size of beans, would certainly make a fine dressing for roads or walks, or excellent filling for asphalt concrete.

Since the handling of the sand by itself is said to be a profitable investment, it ought to be made much more so by quarrying the building stone more extensively instead of using all surface material, and also by seeking a market for the quartz fragments now wasted.

Cornwall — There is no quarry regularly operated at Cornwall, but there are a number of buildings, probably 20 or more, constructed of brownstone, quarried from various points in the hills about the town.

The North Cornwall depot, offices and other buildings about the iron mines are constructed of this stone. The handsomest and most expensive of any of the buildings is the palatial mansion of Mr. Robert Coleman, standing in an unfinished condition, but on which it is said $125,000 have been expended. It is constructed entirely of this stone, with much fine carved work, and is a building of rare beauty. Care has been taken in the selection of the stone in the Coleman house, and as a result the stone is uniform in grain and color, and free from pebbles. In the other buildings the stone contains pebbles, which mars the beauty of the building to some extent, although it looks fairly well on a rock face.

In the country south of Cornwall as far as New Hope station, on the Cornwall railroad, there are many farm houses and barns constructed of stone said to have been obtained by quarrying the loose boulders and outcropping ledges in the adjoining hills. So far as is known to the writer, there is no established quarry in this region.

Schaefferstown and Kleinfeltersville. — There are several small streams breaking through the sandstone mountains south of Schaefferstown and Kleinfeltersville, flowing from the Lebanon limestone valley into the Lancaster limestone valley, through the intervening high sandstone mountains. Along these stream-courses, known as gaps, there are large quantities of brownstone exposed, much of it containing pebbles, but some layers free from pebbles, and most of it a warm, light brown color.

The gaps in which stone has been quarried are in order from west to east, Hammer Creek gap, Elizabeth Creek gap, Segloch gap and Middle Creek gap. No brownstone, as far as could be learned, has been quarried west of Hammer Creek gap, between that and Cornwall.

Along the hill on the east side of Hammer creek, considerable

stone has been quarried from the surface rock, nearly all of it, so far as could be observed, containing pebbles, and in no place worked to a depth of more than 8 or 10 feet.

Stone of better quality was observed in Elizabeth Creek gap than in any of the others. In three different places layers from 8 to 10 feet thick occur almost entirely free from pebbles. Stone in limited quantities has been taken out of this gap, as it has been in several others, and shipped to Columbia, Lebanon and Lancaster, for use in both plain masonry and trimmings, such as cornices, lintels, water tables, steps, etc. Considerable stone from these mountains is said to be used in Lancaster. Mr. Joseph Watson, of Schaefferstown, has been quarrying stone in a small way in the vicinity of Elizabeth gap for 30 years, using the product in the cities above named and in the smaller towns in the surrounding country.

The best stone observed in Elizabeth gap was on the property of William Wagner, in a branch ravine some distance from the Elizabeth creek.

Beautiful stone of good texture and pleasing color has been quarried in small quantities in this vicinity, but it is questionable whether it could be quarried profitably in large quantities, owing to the relative thinness of the beds free from pebbles, and the great quantity of conglomerate associated with it, with transportation facilities, so that the conglomerate could be quarried with profit in large quantities for bridge, stone or heavy masonry then the even-grained sandstone might be obtained in marketable quantities.

In Segloch gap surface stone has been quarried in small quantities, but so far as observed contains many pebbles. Coarse stone for heavy masonry could be obtained.

On Black Oak Ridge, on the west side of Middle Creek gap, south of Kleinfeltersville, the conglomerate brown sandstone outcrops in large quantities. The strata in this place stand nearly vertical (75 to 80 degrees, North 10 degrees East), the harder, more durable layers, projecting in dike-like walls in places. As at Segloch, the rock contains many pebbles. It has been quarried for local use in farm buildings and bridges; some is said to have been shipped for use in bridges on the Pennsylvania Railroad near Philadelphia.

The property from which the stone has been quarried in the Middle Creek gap belongs to Thurber and Weigle, each of whom has a nice residence in town erected of brownstone obtained from some one or more of these gaps in the mountains south of town.

The region between Middle Creek gap and Mohnsville was not traversed, as no quarries of even local importance were reported. The same is true of the middle and south side of the mountains through Lancaster county.

Reading.— In Reading brownstone from three localities has been

used: (1), the native stone from the hills about Mohnsville south of Reading; (2) the Hummelstown stone, and (3) the light pink stone from south of Birdsboro. The first of these, while of inferior quality to the others, has been used more extensively than the others because of its proximity to town.

Mohnsville — The stone known as the Mohnsville stone has been quarried from three openings on the sides of the valley about two miles south of Mohnsville. There are other abandoned openings, but only three now in operation. As the nearest railway point is Reading, nearly eight miles away, all the stone used in Reading or shipped to other towns must be transported by wagon that distance.

Stone has been shipped to Columbia, Pottstown and Minersville, yet the greater part of the product is used in Reading or the country adjoining, many country school houses and churches being built of it.

The buildings in Reading constructed of it are the Catholic church on Perkiomen Avenue, Keystone National Bank, the Stevens building, and several school houses and private dwellings.

The three parties quarrying stone at present (1896) are John Westley, Amos Price, and Daniel Shonour.

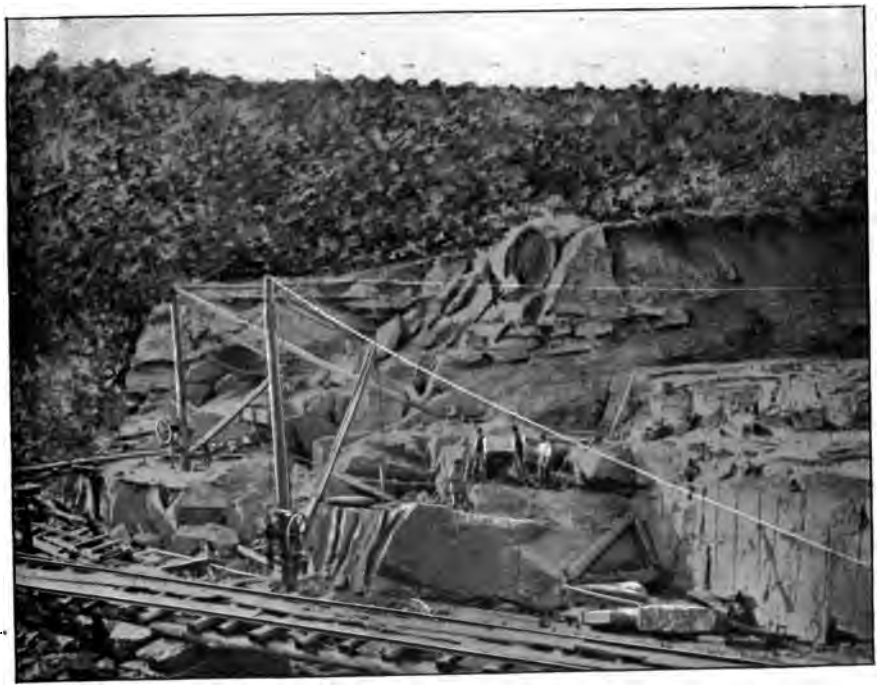
Westley's quarry is the one nearest to Mohnsville. Mr. Westley has been quarrying stone here since 1880 and now has quite an extensive stone trade considering the long wagon transportation.

The stone has a dark brown color as dark as the New England brownstone. It has a rather porous texture, a medium coarse grain, with a great deal of associated conglomerate, heavy beds of conglomerate overlying and underlying the sandstone bed in the quarry and pebbles scattered through the quarry bed. While much of the stone quarried is free from pebbles there is a great deal used with pebbles scattered through it more or less abundantly so that the stone is better adapted to rock-face work than to fine tool-dressed work.

The quarry is located on the slope of the ridge 150 or 200 feet above the valley. The dip of the strata is a low angle to the surface of the hill and the strike runs at an angle to the direction of the hill, so that the quarry opening along the strike of the rock runs up and down the hill. On the upper side near to the top of the hill the opening has been carried along the hill with the dip, thus giving a face in two directions. The thickness of the bed quarried averages about 10 to 12 feet, a little thicker in some places. As it is underlain by conglomerate, a much greater thickness can be obtained by including the conglomerate. The accompanying illustration (No. 2 on Plate 14) shows the position of the stone and method of quarrying.

The next quarry above Westley's, but on the opposite side of the valley belongs to Amos Price, who has operated it for about six years previous to which he quarried from another opening about

Conglomerate from the brownstone south of Birdsboro. View on the bedding surface showing size and distribution of the pebbles.



View in John Westley's quarry, Mohnsville, Pa. Showing structure of the stone and method of working.

one-fourth mile from the present one for six or seven years. Price's quarry is worked less extensively than Westley's. It has a much smaller opening, the stone has a larger face, 25 to 30 feet, but the greater part of it contains pebbles. There is, however, a little very handsome brownstone, a better color and texture than any observed elsewhere in this region, but it is in such small proportion to the other rock that it has no great commercial value. The dip in this quarry is into the hill so that it cannot be worked as deep as the one on the other side of the valley, owing to the rapid increase in thickness of the overlying material.

Shonour's quarry is about half a mile up the valley (west) from Price's. The opening worked at present (Oct., '96). is on the south side of the valley, but there are several openings on each side of the valley, none of them of any great depth, as all the stone quarried has been taken from near the surface. As at the other quarries, there is much conglomerate and some nice sandstone.

The great quantity of associated conglomerate and scattered pebbles will prevent the Mohnsville stone from having a national reputation and ranking with high class building stones, yet its durability, comparatively large quantity, and ease of quarrying are sufficient to always insure a local market for it in moderate quantity.

Birdsboro.—There are four classes of stone in the vicinity of Birdsboro, which have been used for building: 1, a hard red shale; 2, a coarse red sandstone; 3, a light colored pink sandstone; 4, trap.

The red shale occurs in the immediate vicinity of the town. It has been quarried in the town and for a mile or more south of the town. There is no large quarry opening, but a great many small ones, from which stone has been taken for more than 30 buildings, mostly dwelling houses, in the town, and many farm houses in the surrounding country.

It is remarkable to find a durable stone in shale as it is the nature of most shales to crumble on exposure. This, however, contains considerable sand, probably an arenaceous shale and shows great durability. Some of the houses above mentioned are said to be more than 100 years old, built, it is said, as early as 1740, yet they appear to be in a good state of preservation. They are all a cheap grade of houses, many of them plastered with mortar spread over the outside of the wall. Part of the plaster has scaled off, showing a homely patchwork of brownstone and gray plaster.

There are two large quarries of the trap about a mile south of the village. Nearly all the trap rock quarried is used for crushed stone, 25 to 30 carloads per day being turned out. Some of it has been used for building.

South of the trap are heavy beds of red sandstone and conglomerate, some of the conglomerate being quite coarse. Two quarries both close together, have been opened in this rock along the Wil-

mington and Northern railroad, about 2 miles south of Birdsboro, on the east (here the south) side of Hays creek and on the north slope of the hill with the strata dipping nearly north at about the same angle as the slope of the hill, so that the surface of the hill at this place is nearly confined to one stratum of rock. The solid rock in many places outcrops on the surface over considerable areas and rarely has more than a few inches of soil covering.

In the lower quarry the stone has been opened at the base of the hill and up the slope to a height of about 100 feet and 20 to 25 feet deep. The upper opening is a little smaller.

The stone has a comparatively uniform dark brown color, not quite so dark as the New England stone. It contains a great many pebbles, some quite large ones, 4 to 6 inches in diameter. The pebbles are arranged mostly in irregular layers a few inches thick, scattered through the strata, but occasionally isolated ones will be found in the midst of fine grained sandstone. In places there will be a thickness of several feet free from pebbles, but in no place observed could this stone be quarried alone with profit, but by working the stone on a large scale and using the coarse stone for bridge work and heavy masonry, the fine grained stone could be obtained in marketable quantity, and the whole might be worked with considerable profit. See No. 1 on Plate 18, which shows view of the bedding plane in the conglomerate. This is from a photograph of a block which had split parallel to the bedding and was turned on edge. It is the coarsest part of the bed. Crushing tests on 2-inch cubes of stone from this quarry made in the Mechanical laboratory at State College showed results as follows: 41,500; 47,240; 48,640; averaging 45,790 or 11,448 pounds per square inch.

Numerous exposures of the stone occur, both above and below the quarry in the valley, but so far as observed, none were less free from conglomerate than that in the quarry and in most places the pebbles were more numerous.

The quarry was opened by Mr. James Humphrey about 1890 and continued in operation for 4 or 5 years, but it is idle at present and the switch from the railroad partly torn up.

Further south in the valley and on the bordering hills considerable quantities of a handsome light pink sandstone has been quarried at different points, the most important points said to be near White Bear station on the Wilmington and Northern railroad. The localities were not visited by the writer, but stone dealers familiar with the region say there is no large quarry, but that the work has been altogether in surface stone obtained here and there where easy of access. There are several houses in Reading constructed of this light colored stone, the most expensive one being the residence of J. H. Sternbergh, one of the handsomest buildings in Reading, located opposite the entrance to the Chas. Evans cemetery. (See Plate 19, No. 2). The

Bucks County Court House, Doylestown, Pa., Lumberville and Yardley brownstone.

J. H. Sternberg's residence, Reading, Pa. Berks county pink sandstone.
Showing Pennsylvania brownstones in public and private buildings.

trimmings of this building are of light colored Indiana limestone. Mr. Sternbergh states that the stone for his house came from near Geiger's Mills near the line of the Wilmington and Northern railroad, about 15 miles south of Reading, and to the best of his knowledge had never before been used in Reading. He obtained all the stone from surface boulders and says that it has been quarried in considerable quantities since, but not in any defined quarry opening. Mr. Yocum's house, constructed of this stone, has the trimmings in brownstone. The gateway to Mr. Brook's house at Birdsboro is of this pink stone.

So far as observed this pink stone is not free from pebbles, but the pebbles are small, forming either a coarse sand stone with a few small pebbles or a fine conglomerate with much sand.

The stone presents a pleasing appearance in rock face work, both rubble and course work. The color is attractive and looks well either in walls or in trimmings, but the coarse texture renders it unsuitable for fine cut work. This stone while not regularly in the market, is known to the local dealers and quarrymen, and it is said can be procured on demand in small quantities.

Similar pink sandstone is said to occur also on the south side of the ridge in the Conestoga valley. J. H. Brinton of Thornbury advertises a pink stone from Conestoga valley, stating that it can be furnished in quantities for trimmings or ashlar, and that it is peculiarly adapted for trimmings for his Pennsylvania greenstone. A sample of this Conestoga pink sandstone received at the college resembles that used in Reading and Birdsboro, but a request for further information elicited no response.

The beautiful color of this stone and the demand for such stone at the present time would justify a careful investigation of this area.

Phœnixville. —Brownstone of inferior quality has been quarried in a number of places in the vicinity of Phœnixville

There is a small brownstone quarry on Bridge street in the west side of the town that is said to belong to Mr. Malin Miller. It is now abandoned and apparently has been for some time, for a number of years at least. The stone has been quarried over an area of a half acre or more to a depth of 20 to 25 feet with 5 to 20 feet of brownstone overlain by 6 to 10 feet of red shale. The stone has numerous seams, in places shelly along the seams. It has a dark brown color, darker on the surface than in the interior.

No information could be obtained regarding the time this quarry was in operation, the amount of stone produced or the use to which it was put.

There is a quarry on the hill above Mount Clare, just across the river from Phœnixville The stone on the quarry face is a dark

gray, rusty brown and black shale. What it was used for could not be ascertained, but it is apparently too much laminated for use as building stone. See No. 1 on Plate 20 for view in the quarry.

A small quantity of brownstone has been quarried at Berwyn, below Phœnixville for use in the water works at that place, but there is no regular quarry.

Mr. Gotwals, of Phœnixville, states that brownstone has been quarried in small quantities near Kimberton on the Pickering Valley railroad, also near Yerkes station on the Perkiomen railroad, on the property of John Gotwals and on the Buckwalter place, where stone was obtained for constructing the bridges when the railroad was built. Flagstone has also been obtained. None of these localities was visited by the writer.

Valley Forge.—Brownstone has been quarried along the Schuylkill river, both above and below Valley Forge. About mid-way between Valley Forge and Perkiomen Junction on the south side of the river is a brownstone quarry said to belong to Newton Walker, but it has not been operated for several years. The opening covers about a quarter of an acre, 15 to 20 feet deep. The stone which is of inferior quality, is of purplish brown color, coarse-grained texture, many joints and seams and much false bedding and intercalary shale. Some conglomerate occurs which contains both quartz and shale pebbles.

While but 15 to 20 feet of stone has been quarried the bed has a thickness of not less than 200 feet, some of the underlying stone being fully equal, if not superior, to that which has been quarried, yet it is all more or less defective throughout, containing streaks of conglomerate and shale. The bedding is not regular.

About mid-way between Valley Forge and Port Kennedy is a brownstone quarry said to belong to Charles Johnson. It has been opened recently and worked only on a small scale. There is a thickness of 15 to 18 feet of solid, coarse-grained brownstone.

Norristown, Port Kennedy and vicinity. — Large quantities of stone have been quarried in the vicinity of Norristown along both the Pennsylvania railroad and the Philadelphia and Reading railroad.

On the north side of the Schuylkill river there are quarries on the bluff on the east side of town, on the east side of Montgomery cemetery, on the west side, and at intervals along the Pennsylvania railroad up as far as Betzwood station, where the large quarry of the Port Kennedy Stone Company is located. On the south side of the Schuylkill there are quarries, on the west side of Bridgeport, and those enumerated about midway between Valley Forge and Port Kennedy and a mile or more above Valley Forge, below Perkiomen Junction.

The stone has had an extensive local usage for building and considerable quantities have been shipped to Philadelphia and vicinity.

Brown shale quarry, Mount Clare, Pa.

Kennedy's brownstone (light-colored) quarry, Fort Washington, Pa.

Quarries in the New Red formation in Montgomery county.

quarry below the cemetery, which is the largest opening of all, the stone is light colored and coarse grained. No particulars could be obtained in regard to the quarry as to when it was operated and the use made of the stone.

A church and several dwelling houses were noticed by the writer in Norristown that were constructed of stone similar in color and appearance to the stone in this quarry, and thought to be from this and neighboring quarries.

There is another quarry opening that was not visited by the writer in the lower (east) side of Norristown, that from a distance appears to have a light colored stone.

There are three quarry openings on the south side of the Schuylkill river, opposite Norristown and west of Bridgeport. The most eastern one of these, the one nearest town, is operated by J. L. Tyson who has had charge of it since 1881. It was operated by other parties for several years previous to that date. The stone occurs in irregular layers with many vertical seams, especially numerous near the outcrop, thus dividing the stone into small dimensions. (See No. 1, Plate 21).

The stone has a light gray color, and coarse texture, merging into conglomerate in many places, with a few intercalary streaks of shale. It occurs in irregular layers six inches to three feet thick, the entire thickness of stone shown on the present face aggregating 45 to 50 feet, overlain by 20 to 30 feet of red shale and three to twelve feet of yellow sand and sandstone, the red shale containing thin layers of hard sandstone. The quarry, in fact none of the quarries here were in operation at the time of my visit, Oct. 19, 1896. It is said to employ 20 to 30 men and ships most of the stone to Philadelphia for use in foundations.

About 250 yards above, N. W. of, Tyson's quarry is another fully as large, said to belong to Mr. Schenlein and operated until recently by Mr. John Brown. It is in layers which overlie those in the Tyson quarry. It contains more and coarser conglomerate than Tyson's quarry, some of the pebbles being as large as hen's eggs, and in some places so feebly cemented that they drop out on the exposure of the rocks, giving the face of the quarry a pitted appearance.

About 100 yards northwest from the Schenlein quarry is another quarry said to have been opened by Mr. Brown after he left the Schenlein quarry. The stone is somewhat similar to that in the last quarry, but more uniform in color and texture, having much less conglomerate. Some nice brownstone could be obtained here along with much that is pebbly. The microscope shows the stone to be made up of large angular quartz and feldspar grains, the feldspar consisting of both the alkali and basic feldspar, the latter predominating. There are a few small mica scales and considerable clay and granular quartz. See No. 2 on Plate 21.

Brown's quarry.

Tyson's quarry,

Views in the brownstone quarries near Norristown, Pa. Showing structure and depth of weathering.

Fort Washington.—About half a mile above Fort Washington station on the Philadelphia and Reading railroad, on the east side of the railroad, are two quarries of very light colored brownstone, so light in color as to be more properly termed gray. They are in strata in the New Red formation which contains the true brownstone quarries. So that it is put here more on account of its geologic relations than because of the color.

The stone is coarse-grained, made up of grains of white quartz and white and pink feldspar, with some associated mica.

In the larger of the two quarries which is owned by Mr. Kennedy and worked by Mr. Burl, the stone is 30 to 35 feet thick, overlain by 3 to 6 feet of sand and boulders. There are many weather seams cutting the stone into small dimensions. In a few places blocks as large as 3 to 4 feet across are obtainable, but the greater part of it is in small dimensions, so far as can be judged by the quarry face.

The stone has been used locally for building. The handsome residence of Mr. Kennedy and probably not less than a dozen other houses in the vicinity, and a number of buildings at Ambler, are constructed wholly or in large part, of stone from these quarries. (See No. 2 Plate 20).

The smaller quarry known as Wallace's quarry is not now (1896) in operation.

Doylestown.— There are several quarries of local importance in the vicinity of Doylestown, and in a number of places stone has been gathered from the surface for use in bridges and farm buildings.

The largest quarry so far as known in the vicinity is that run by Joseph Paul at Frog Hollow, near Neshaminy postoffice, six miles south of Doylestown, on the Philadelphia pike. The opening covers an area of about an acre, 20 to 25 feet deep, having 15 to 20 feet of comparatively sound rock, overlain by two to four feet of red sand, shelly stone and soil. The strata dip, 10 to 12 degrees to the north. There are two marked systems of joints, one north-south, one east-west, from one to four feet apart. Nearly all the stone can be moved from its position in the bed by wedging or by the use of a bar. Powder is used to some extent for breaking up the larger blocks.

The stone has a rather dark brown color, spotted in places, with iron rust. It is very fine grained, finer than the average brownstone. There are a few feldspar grains mixed with the quartz, nearly all the grains having a thin coat of red hematite which also occurs in grains scattered through the rock.

The quarry was opened, it is said, not less than 50 years ago. Mr. Paul has had charge of it for 20 years. He employs from two to four men, and the product of the quarry is all used locally, the nearest railway points being Doylestown on the north and Willow Grove on the south, each six miles away. The almshouse hospital, about four miles north of the quarry, is said to be constructed of this stone.

Stone has been quarried for cellar walls and road metal below the stone bridge at Edison postoffice, a mile and a half south of Doylestown, but none of it is suitable for dimension stone.

The stone arch bridge across Neshaminy creek at this point (Edison postoffice) is made of native stone, but inquiry could not locate the spot more closely than that it was made of stone picked up on the adjoining hills. It was constructed in 1800, many years before the railroad was built, and it is in a remarkably good state of preservation, no signs of decay noticeable anywhere on the bridge. It speaks well for the durability of the stone. (See Plate III, No. 1.)

A. P. Loux, Tradesville, Pa., has opened a quarry on his farm, two miles south of Doylestown, where stone has been taken out in small quantities for local usage. The Jewish school building now (October, 1896) being erected, one-half mile northwest of the quarry, is of stone from this quarry. There are several small openings, none of which have penetrated more than 15 or 20 feet and consequently not beneath the weathering influences, the numerous weather seams cutting the rock into small dimensions. The rock has a light gray color, with a brownish tint. The surface along all of the seams has a dark brown stain. There are a few spots of conglomerate, but much of it has an even medium coarse grain, the grains composed of quartz and feldspar, the quartz grains interlocking in places; there is some interstitial clay and granular quartz.

Grenoble.— There is a quarry of very light colored brownstone on the east side of the Philadelphia and Reading railroad, close to the track, about two hundred yards south of Grenoble station, Bucks county. It has been operated by Moody & Edwards since October, 1895. It was not in operation in 1894, and had been worked by Mr. Ryan, of Philadelphia, during 1892-93 and Jameson & Ryan in 1891.

There is about 22 feet of fairly sound stone, overlain by three to eight feet of shelly rock, largely waste, three to six feet of red sand and shale, and one to four feet of yellow sand. The rock is cut up by numerous seams, so that most of the stone comes out in small dimensions, made still smaller by the liberal use of powder in quarrying. A large part of the product goes for cellar walls, rubble work and similar uses. Some large dimension stone is obtained. The color is a very light brown, the grain finer than the average, and in a few places it is slightly cross-grained, but not to any great extent. It is made up of a closely aggregated mass of quartz and feldspar, the latter much decayed, considerable hematite coating the quartz and feldspar and in grains diffused through the rock.

The company employs from 12 to 22 men in the quarry and ships stone to different places in Pennsylvania and New Jersey—at present (October, 1896) they are filling an order for Camden, New Jersey.

The railway station at Grenoble, a neat, little brownstone structure, is made of stone from this quarry, which is also used in a number of schoolhouses in the surrounding country.

There is a small abandoned opening on the north bluff of the Neshaminy creek, half a mile west of Grenoble station, where the rock is darker colored than that on the railroad and very shelly where exposed. It is overlain by a heavy bed of red shale.

Along the railway north of Grenoble station and half a mile south of Rushland station, there are large exposures of red shale, 50 to 75 feet thick, but no rock of commercial importance.

North and Northeast of Rushland station are exposures of black shale, weathering rusty brown on exposure. It is quarried about a quarter of a mile north of Rushland and crushed for road material.

C. Northeast end of the New Red Brownstone Area.

Newtown, Yardley, Carversville and Lumberville.

Newtown. — There is but one quarry at Newtown that produces building stone; that is operated by Mr. Mitchell, who has had charge of it for 14 years, and who operated the Yardley quarry for the nine years preceding.

The quarry is nearly two miles west of Newtown and nearly two and one-half miles from the railroad. The stone that is shipped by rail it is necessary to haul this distance. However, much of the stone delivered within a radius of 10 to 14 miles is wagoned the entire distance, as it is thought to be cheaper than the extra handling in the haul at each end of the road. Stone is hauled by wagon to Trenton, N. J., 10 miles away.

As might be judged from the shipping facilities, the stone is largely cut-stone of good quality, as there would be no profit with low priced stone with such expensive transportation.

The stone is somewhat similar in character to the Yardley stone, but has a lighter, brighter, more uniform color and more even grain than much of the Yardley stone.

The color is a light brown, with a purple tinge, and comparatively uniform. It has a medium fine grain and fairly uniform texture throughout. There are a few bands toward the bottom, two to four inches thick, which contain shale fragments sometimes in sufficient quantities to give the stone a darker color, and in all cases injuring the quality of the stone. It is slightly cross-grained in a few places, but the great mass of the stone is fairly uniform.

It is more feldspathic than the stone further west as shown both by the chemical and microscopical examination.

Chemical analysis of Newtown brownstone.

Silica (SiO_2),	82.34
Alumina (Al_2O_3),	11.46
Iron oxide Fe_2O_3),	1.07
Lime (CaO),	.27
Magnesia (MgO),	.19
Manganese oxide (MnO_2),	.07
Potash (K_2O),	.17
Soda (Na_2O),	3.76
Water (H_2O),	.80
Total,	100.13
Specific gravity,	2.66

The decreased percentage of silica and the increase of alumina and soda indicate an increased percentage of feldspar or feldspathic material over the Hummelstown stone, which fact is shown the more clearly in the microscopic section (Fig. 5), which, when compared

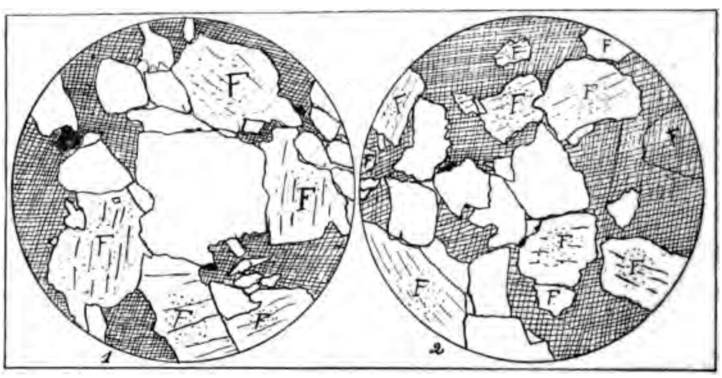


Fig. 5.—Microscopic sections of brownstone from Mitchell's quarry (1) and the Yardley quarry (2). F, is feldspar; the cross line areas, aggregates of clay and finely granular quartz; the colorless areas quartz grains. Enlarged 44 diameters.

with sections of stone from the other localities (see Plates I and 10), shows the increased amount of feldspar. There is a large percentage of granular quartz diffused through the clay cement and a considerable percentage of the iron oxide is segregated in small lumps through the clay. A trace of mica was observed in the occurrence of a few very minute flakes.

The stone is much softer and lacks that brittle quartzose character of the Lumberville and Stockton stone. It cuts and dresses freely and works more easily than the average brownstone. It splits easily with the grain, without even drilling holes, by simply driving in

small wedges. Across the grain it is split by drilling holes, six to twenty inches deep, depending on the size of the block to be split, and driving in wedges.

There is a thickness of 35 feet of solid stone, overlain by 35 feet of shaly sandstone, red shale and yellow sand at the west end, thinning to one or two feet at the east end. It all lies above water level on the north bluff of the Neshaminy creek.

The strata dip N. 10 degrees, E. 12 to 15 degrees, so that the stripping increases rapidly in working back into the hill. An admirable economic feature of the stone is the joint seams. There are two systems, one N. 10 E., one N. 90 E., which are very regular, with smooth faces and from four to twenty feet apart, thus subdividing the bed into roughly rectangular blocks of different sizes. By having a face of considerable extent, Mr. Mitchell finds it easy to split off blocks of any required dimension from some point along the face with very little waste by selecting the block of the proper width. The jointing is shown on the accompanying view of the quarry, figure 6.

Fig. 6.—Mitchell's Quarry, Newtown, Pa., showing thickness of layers, system of jointing and amount of stripping.

The stone has been used extensively for trimmings for both stone and brick buildings and a number of buildings are constructed of it entirely. It is a stone easily carved and looks well either on rock face or tool dressed.

Some of the buildings in which it has been used are the German Hospital, Philadelphia; Convent of the Good Shepherd, Chew street, Germantown; Episcopal Hospital, Germantown; the First National Bank, Presbyterian and Methodist churches, addition to the public school building, and a number of handsome private residences in Newtown.

Watson's quarry.—There is a small quarry about half a mile south of the village of Newtown operated by Mr. Charles Watson, which produces crushed stone for macadamizing roads. A steam rock crusher was put in two years ago, but has not been in constant operation. The stone has a dark brown color, is hard and brittle and contains much more iron oxide than that at Mitchell's quarry.

There is about fifteen feet of brownstone overlain by three to five feet of soil and red shale. The strata dip 10 degrees N., 20 degrees W., with numerous seams east-west and north-south. None of this stone is used for building except a very little for cellar walls.

The brownstone outcrops in several places in the vicinity of Newtown, in places of very similar character to that in Mitchell's quarry. The approximate line of these outcrops is shown on the Bucks-Montgomery county maps made by Dr. Lyman.*

The creek in the town flows over a solid bed of brownstone, which shows in the bottom of the creek.

The stone is exposed in a number of places along the road between Mitchell's quarry and the town, also on the Doylestown road, northwest of the town. About one and one-half miles northwest of the town on the Doylestown road, the outcrop shows several feet of the sandstone in a massive ledge, where a good, workable stone would likely be found close to the surface. In most places the stone is quite shelly on the outcrop.

Yardley.—There are several grades of stone and a number of small quarry openings in the vicinity of Yardley. Two of the largest quarries, known as the Yardley and Nicholson quarries, are in stone similar in their general character, and resembling somewhat the Newtown stone.

The stone in these two quarries is a light brown, rather coarse grained soft sandstone, much softer than the Lumberville stone; in fact, softer than almost any of the other brownstones in the State.

The shipping facilities are rather defective, most of the stone being

*See maps accompanying the New Red of Bucks and Montgomery counties, *Volume 3*, part 2, of the Summary Final Report, Pennsylvania Geological Survey, *1895*.

sent by canal, some of it by rail on the Philadelphia and Reading railroad, but neither of the quarries is on the canal or the railroad. The Yardley quarry is about 200 yards from the canal and a mile or more from the railroad. The Nicholson quarry is nearly a half mile from the canal and more than a half mile from the railroad. This is the principal reason, probably, why these quarries are not worked more extensively. Another reason given by some of the quarrymen is that the lease rate is too high.

The Nicholson quarry, one-half mile north of west of the village was first worked probably 100 years or more ago, but previous to the war the work was on a small scale. About 1868 it began to be worked more extensively. In 1873 the Twining Brothers obtained control of it and ran it for about nine years, during which time a great deal of good building stone was taken out. They employed from 25 to 50 men. In the last year or two of their work much of the stone went into bridges, but in previous years it went largely for buildings in Philadelphia and Camden. Mr. Twining says he remembers furnishing stone for at least ten school houses in one year in Philadelphia.

The quarry was operated by Mr. Shevlin for several years after the Twining Brothers left it, but it has been idle now for several years, except occasionally stone is removed in small quantities by different parties for local use.

The quarry opening covers about three acres in extent, 30 to 50 feet deep. A variable thickness of three to fifteen feet at the top consists largely of red brown shale with some interstratified shelly sandstone, with 25 to 35 feet of light purplish brownstone underneath.

The stone is evenly bedded and in the bottom heavily bedded, but one or two bedding seams showing in the 20 to 25 feet from the bottom. There are two sets of joint seams, one N. 20 degrees E. one N. 70 degrees W., the first one being more pronounced. These seams are two to twenty feet apart, thus cutting the stone ino rectangular blocks of varying sizes.

The bottom of the quarry is not perfectly level. Near the southwest corner there is quite a prominence on the quarry floor where the stone dips in various directions.

The color is fairly uniform, being a light purplish gray, in all places being darker on the face of the stone and along the joints than in the interior. This is probably due in large measure to the sediment washed from the overlying red shale by the rains. The stone is soft and works easily. The microscope shows a greater percentage of quartz than that in the Yardley quarry and the feldspar better preserved.

The Yardley quarry is about a half mile north of Yardley and about 200 yards west of the canal, thus having an advantage over

the Nicholson quarry in transportation facilities by water. The quarry was worked for a number of years by Mr. Mitchell, who is now running the Newtown quarry, but is now operated by Mr. James Shevlin, who has had charge of it for eight years. Much of the stone is used for rubble work in Camden and Philadelphia. yet considerable cut stone has been shipped. Some of the buildings in which the stone has been used are a Catholic church at Camden, an addition to the public school building at Camden, Presbyterian church at Easton, wing of the Episcopal Hospital, Front and Lehigh avenues, Philadelphia, and the Doylestown Court House in part. (See list on p. 39.)

The opening is 5 or 6 acres in extent, 30 to 45 feet deep. The stone is weathered to considerable extent, having 3 to 5 feet of yellow soil on top, underlain in turn by 3 to 10 feet of red shale and shaly sandstone and 6 to 8 feet of sandstone with many weather seams and 20 to 25 feet of good stone with seams in numerous places. Much of the stone is in small dimensions which goes largely for rubble work, along with which considerable good dimension stone is obtained. The nicest stone exposed at the present time is in a north wing of the quarry, at the east end where, near the bottom of the quarry, a light pink colored rock occurs that has a very attractive appearance. There is a little quartz conglomerate mixed with it, but not in sufficient quantities to cause much waste. The opening is nearly filled with water, work at the present (Sept., 1896) being carried on at the west end of the quarry, so that the extent of this bright colored stone could not be observed.

The upper part, in places more than half of the stone, can be removed by simply prying it loose from the bed with bars inserted in the seams. In the lower part of the bed where the seams are fewer and not so open powder is used to blast the stone loose.

*Chemical analysis of brownstone from the Yardley quarry.**

Silica (SiO^2),	82.72
Alumina (Al^2O^3),	10.29
Ferric oxide (Fe^2O^3),	1.92
Lime (CaO),	.17
Magnesia (MgO),	36
Manganese oxide (MnO^2),	.16
Potash (K^2O),	.10
Soda (Na^2O),	2.92
Water (H^2O),	1.22
Total,	99.84
Specific gravity,	2.675

*Made in the Chemical laboratory of Pennsylvania State College.

The microscope shows the feldspar to be much decayed in places, only a trace of the original in the resulting clay cement remaining along with numerous fine grains of quartz diffused through the clay and a few small spots of segregated iron oxide in the clay and coating the grains. (See the right side of No. 2 in Fig. 5 on p. 80). The stone is not uniform in texture, having small areas quite quartzose made up of interlocking quartz grains while other areas of equal extent have comparatively no quartz.

There is another quarry about two miles north of Yardley, on the bank of the canal, worked by Mr. William White. The stone is hard red and black shale and slate, no sandstone occurring at this point. It is used for rip rap along the river, no dimension stone being quarried. There is aface of 50 to 60 feet showing:

Soil and shelly rock,.....	6 in.	to	1 foot
Shelly, weathered rock,.....	1 in.	to	3 feet.
Solid red shale, with many seams,.....	6 in.	to	8 feet
Brown shale, with streaks of green,....	10 in.	to	15 feet
Solid red shale,.....			10 feet
Greenish blue shale,.....	0 in.	to	12 feet
Blue-black calcareous shale,.....			10 feet

There are several quarry openings along the canal south of Yardley that were not visited by the writer. The stone is said to be of inferior quality, used only for cellar walls and rough work and the quarries have not been operated for several years. They are in layers that underlie those in the quarries above mentioned. In several places in the vicinity of Yardley, north and northwest of the town are outcrops of brownstone similar to that in the quarries.

The lack of proper transportation facilities prohibits further exploitation. With sufficient capital to build a railway to the quarries, the present ones might be operated more extensively and others opened. The thickness of the bed is not great, but in proportion to the amount of waste, the quantity is equal to that in many quarries worked with profit farther from good markets than these.

Carversville.—The Carversville quarry was not visited by the writer. It was purchased by the Twining Brothers, of Yardley, and operated for them by Mr. Edwards, now at Grenoble, from 1881 to 1885. It was purchased by them primarily in order to get light colored stone to fill a contract in Philadelphia, where the darker colored Yardley stone could not be used. Stone was taken out for various school houses and churches, but the hard stripping, and difficulty in keeping out the water and the distance from the railroad and the canal all combined to make the further working of the quarry unprofitable.

Lumberville. — The Lumberville stone, advertised by one company as the Lumberville granite, while not very brown occurs in the New Red formation, closely associated with brownstone and interstratified with red shales.

The manager of one of the quarries says they call the stone granite for the want of a better name. The stone-cutters refuse to work it as sandstone, and they were compelled to use some other name. . The stone is properly a quartzite or a quartzitic sandstone, but there is so little quartzite used in the trade that the term is not a familiar one among dealers, and so was not used. It is an unfortunate use of the much abused term granite.

Dr. Penrose calls it a "feldspathic quartzite," an appropriate name for the geologist, but still more difficult to introduce into the stone trade than simply quartzite, as feldspar is not a familiar term to many of them.

Mr. Paxson, another of the quarrymen, calls it graystone, a legitimate if not a very definite term.

From the standpoint of the stone-cutter or the merchant there is some excuse for classing it as a granite, as it is not greatly different from an average granite in composition, either chemical or mineralogical, being made up of the detritus from granite rocks, but the basic minerals have decayed to a large extent. It takes granite tools to cut it, being harder than any sandstone.

In its origin or mode of formation it is a sandstone, being composed of granular sedimentary material hardened into rock. It differs from the ordinary sandstone in having the grains more firmly cemented, which causes the greater hardness and differs from ordinary quartzite or quartzitic sandstone in having more foreign material along with the quartz.

In its history it differs from the common sandstone in that a large proportion of its constituents are derived by erosion from fresh granite or granitic rock of some kind, while ordinarily the sand sediment is derived from decayed rocks in which the feldspathic and other complex minerals are broken up and the quartz separated from the other materials. The rock needs to be fused and recrystallized to form granite. Hence, while the term is probably permissible from the stone-cutter's standpoint, it is to be deplored from a scientific point of view.

According to Dr. Lyman's classification, it comes in the same division of the New Red as the Yardley and Newtown quarries, called by him the Norristown shales; but the Lumberville stone is at a somewhat lower horizon than the others, corresponding more nearly with the gray stone along the canal south of Yardley.

The stone is essentially different in hardness as well as color from *any others anywhere* in the New Red formation in the State, so far as

known to the writer. That at Raven Rock and Stockton, N. J., on the other side of the river near by rather closely resembles it, but is not so hard.

It differs from the average brownstone not only in color, but noticeably so in hardness. The prevailing color is a blue gray, with a faint pink tinge, more pronounced in long exposed surfaces, with light brown in places, in some places buff, and in others various shades of gray and blue; and some layers a decided brown. It is only by quarrying on a large quarry face on a large scale and selecting the stone, that a stone of uniform shade of color can be obtained.

The variation in texture is equally as great. It varies from fine-grained to a coarse conglomerate, the conglomerate occurring in thin bands or layers, varying from a fraction of an inch to a foot or more in thickness in the finer grained stone with rarely any line of parting between them. The pebbles are quite variable in composition, some being nearly pure quartz, some feldspathic, and many of a dark red brown shale, so abundant in places as to give the stone a decided dark color.

A partial chemical analysis shows a percentage of silica of 79.58 per cent. with iron oxide, lime and alumina present.

Its extreme hardness is shown (1) by its crushing strength, which is more than 20,000 pounds to the square inch, about four times that of an average sandstone; (2) by the impact test (Johnson), which gave a loss of but .46 per cent.; (3) its absorption, which is 1.12 per cent.; (4) and decidedly the difficulty met in cutting it. The stone-cutters refuse to work it for sandstone, turning it over to the granite cutters.

The hardness is due in part (1), to the interlocking of the angular grains; (2), the presence of some quartz cement binding the grains, and (3), the presence of calcite in the cement, as shown on the accompanying micro-drawing, the one to the left being an exceptionally feldspathic area, the one to the right showing the calcite cement.

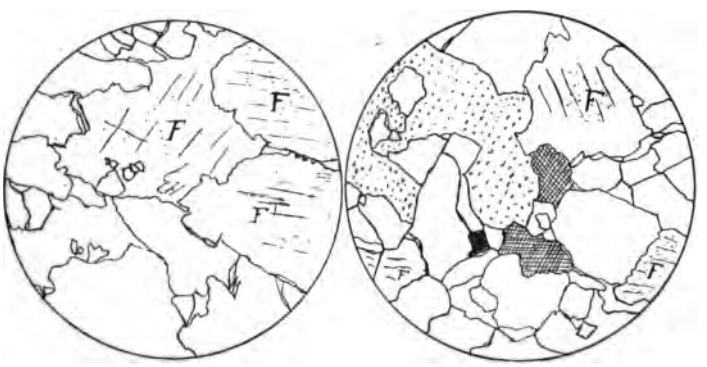


Fig. 7.—Micro-drawings of the Lumberville stone. F is feldspar, the clear areas quartz, the cross-lined areas clay and granular quartz, the dotted area calcite. Magnified 44 diameters.

The stone occurs in heavy bedded, in places almost massive, layers, having a dip west of north. Weathering opens incipient bedding planes, so that near the outcrop the stone occurs in thin layers, but in the interior, beneath the action of the weather, the bedding seams are almost entirely absent, the thin layers merging into a massive bed so far as the bedding planes are concerned. However, there is a system of nearly vertical joints (back seams) running in a nearly southwest-northeast direction at varying distances apart, from a few inches to four or five feet. The cross joints, or wall seams, at right angles to these, are in most places very few, frequently 20 feet or more apart, in consequence the stone on the outcrop is generally cut up by the different seams into small dimensions, which increase in size beneath the surface and in the lower part of the deeper quarries it occurs in blocks as large as can be handled. (See Plate 23.)

The total thickness of the stone at this locality is not known, but must be several hundred feet. The quarries are all in different layers, the dip of the rock being 12 to 13 degrees N. 35 degrees W. (varying in different places), the lowest (most easterly) quarries being in the lowest layers, the quarries farthest west being the highest in the series.

While the joint seams are quite regular and uniform in direction, there is in many places a thickness of an inch or more along the joint surface that is quite scaly. While the material in these separate thin scales or layers is very hard and firm the rock is rendered shelly for an inch or two along the seam by these small joint planes paralleling the larger ones.

The grain of the stone is remarkably straight, which largely compensates for the excessive hardness in the quarrying of the stone. To split large blocks it is only necessary to put in a few shallow drill holes, and drive in wedges to produce a break remarkably straight and even.

The quarrying of the stone is made very simple and comparatively easy by utilizing the joint seams. These seams vary a few degrees from the vertical and after getting an opening made to the required depth it is only necessary to throw down these nearly vertical layers one after the other. This may be done sometimes by merely prying them loose with a bar, while sometimes a small charge of powder is used. In some of the openings they work under the leaning layers, thus utilizing the gravity of the stone and greatly economizing the force necessary to move the blocks. In some of the lesser openings they work from the other side, which necessitates a much greater force to move the stone.

The crushing strength of the stone is very much higher than any of the commoner sandstones as may be seen on consulting the table

1. At right angles to the plane of the joints.

2. In the line of the joints.

Views in the Lumberville quarries, showing the joint structure.

on page 30. Four specimens, tested at Fairbank's laboratory in New York City, gave the following results in pounds per square inch: No. 1, 20,180 pounds; No. 2, 21,080 pounds; No. 3, 21,780 pounds; No. 4, 16,540 pounds making an average of 19,895 pounds per square inch for the four. However, two of the specimens (Nos. 2 and 4) had been subjected to freezing tests before crushing, and taking the two fresh specimens (Nos. 1 and 3) the average would be 20,980.

Two samples tested in Philadelphia in the laboratory of Booth, Garrett and Blair, August, 1896, gave an average of 24,625 pounds per square inch.

Tests on the shearing stress made by Prof. Garrison, of the Franklin Institute, gave for four specimens the following result: No. 1, 6,990 pounds per square inch; No. 2, 2,370; No. 3, 5,560; No. 4, 6,360, giving an average of 5,320 pounds per square inch.

Absorption tests made on two specimens after immersion for twenty-four hours gave 1.04 per cent. and 1.11 per cent., an average of 1.07 per cent.*

The stone has a specific gravity of 2,595, weighing 162 pounds per cubic foot.

All the above tests were made on samples from the quarries of the Lumberville Granite Company, and published in their circular.

They show a stone of hardness and strength, about the same as the Laurel Run and White Haven red stone.

The Lumberville stone has been used extensively in Philadelphia for Belgian blocks in paving along the street car lines. Its hardness makes it stand the wear remarkably well, the granularity prevents it from growing slippery and the straight grain assists in the splitting of the stone into proper dimensions.

Experience appears to sustain the results indicated by the foregoing tests. L. M. Haupt, civil engineer (Company's Circular), says that he has examined the pavement on Chestnut street, Philadelphia, Pennsylvania, that has been down about eight years and subject to the heavy traffic of that business street and finds no appreciable signs of wear, many of the blocks showing the original quarry marks.

The making and shipping of these blocks have been carried on quite extensively at this place.

It has been used to some extent for building in different places, St. John's College, Brooklyn; Mr. Rodenbaugh's house, Easton, and Mr. Robert Wright's home in Allentown, being some of the buildings constructed of it. Others are enumerated in the table on p. 39.

The stone is nearly all shipped by boat on the Delaware division of the Lehigh canal, which is a ready means of transportation to Phila-

*Made in the department of tests, Stevens Institute of Technology, at Hoboken, New Jersey.

delphia, Camden and intermediate points along the Delaware valley, as well as towns up the Lehigh valley.The Lumberville Granite Company has fitted up a wire cable way across the river to the Belvidere division of the Pennsylvania railroad, by means of which stone can be delivered on the cars with great rapidity.

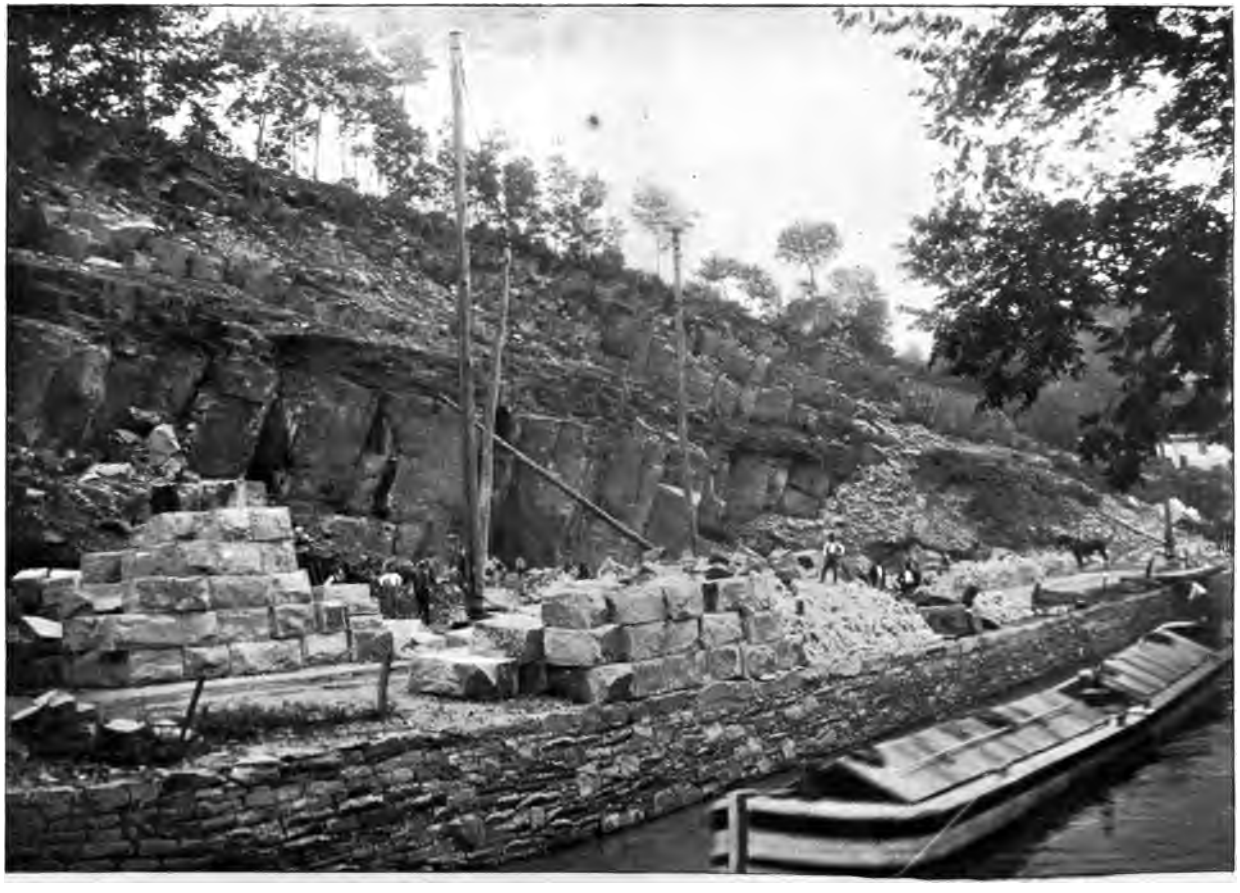
There are six or more openings, all located along the banks of the canal on the west (south) side of the Delaware river.

The two upper, most westerly, openings belong to the Lumberville Granite Company, which is the largest producer in this locality. The upper opening, which is now abandoned, has 50 or 60 feet of stone exposed, and in one place an opening of considerable extent below the quarry floor, now filled with water. There are numerous seams in a northeast-southwest direction, cutting the stone into rather small dimensions. There is a bed of shale overlying the sandstone, and one lenticular streak of shale in the body of the stone.

The next opening, which is being worked at the present time, is separated from the first mentioned by a wall 30 to 40 feet thick, called by the operator the "Ragged Edge," consisting of stone much seamed and broken. The hill is much higher at this point hence a much greater thickness of the stone is worked. It is said to be 135 feet at the highest point of the quarry face. The seams are further apart than in the other opening, hence the stone occurs in larger dimensions. There is a lens-shaped mass of red shale in one place in the quarry face and on another place an irregular mass of dark colored shale. The rock varies considerably in texture, having streaks of conglomerate interspersed with fine grained stone. By having a large quarry face and taking the stone out in large quantities it is possible to select material uniform in grain and color. Much of the stone has been used as paving blocks.

The next quarry, the first one below the grist mill, belongs to W. F. Paxson. It occurs in strata lying underneath those in the quarries above mentioned. The hill is not so abrupt at this point and the quarry face not so high, being 40 to 50 feet. There is about 30 feet of purplish gray stone at the base, overlain by 6 to 10 feet of red shale, followed by a constantly increased thickness of light colored shelly sandstone with many seams. As in the other quarries, the stone is not uniform throughout, having streaks of conglomerate and shale, but the greater part of the bed is stone of good quality. Plate 23 gives a view in this quarry showing its proximity to the canal and facilities for loading and shipping. Much of the stone from Paxson's quarry is used for building.

The next two openings toward the east were made by Thomas Conner, of Centre Bridge. He furnished some cut stone for Fairmount Park, Philadelphia, but all the remainder of the stone from his quar-



Paxson's Quarry, Lumberton, Pa., Showing structure of the stone and facilities for loading and

ries was used for common rubble masonry, shipped by boat and sold by the perch in Philadelphia and Camden. The stone is somewhat similar to that in the quarries above mentioned, but there is a much heavier stripping and more shale and conglomerate mixed in the stone.

The next two openings to the east are said to have been made by J. M. Samsell, of Mt. Pleasant. The face of the quarry shows from 50 to 80 feet of stone, 3 to 20 feet of weathered shelly material at the top. The upper half of the quarry contains many more seams than the lower half, due to the weathering influences.

There is said to be a small quarry above Lumberville which produces crushed stone. There are several quarries on the New Jersey side of the river at Raven Rock and Stockton. (Described later under the head of New Jersey.)

D. The Mauch Chunk Red Stone.

The Mauch Chunk red shale or the "red shale," as it is frequently called throughout the eastern part of the State, occurs in the Lower Carboniferous rocks, immediately underneath the heavy beds of Pottsville conglomerate which forms the base of the Coal Measures. While it is largely composed of a bright red shale, in many localities, notably along the eastern borders of the area, there is a great deal of hard red and brown quartzitic sandstone, and conglomerate.

The red quartzite or quartzitic sandstone is as brown and in that sense as much of a brownstone as that in the New Red or Mesozoic age. It differs greatly, however, in its physical character from much of the brownstone in the markets, but it must be remembered that there are great variations in the brownstone of the New Red formation. So far as the economic use of the stone is concerned this is as much a brownstone as though it came from the rocks of Mesozoic age.

Na' m The stone is very hard as compared with sandstone, as already stated. So hard is it that one of the quarries markets it as red "granite;" another does not go quite so far, but calls it simply "red stone." There is the same reason for using the term granite instead of sandstone here as at Lumberville, namely that the sandstone cutters refuse to cut the stone, saying emphatically that it is not sandstone and the ordinary sandstone tools will not cut it. While it is more easily broken and chipped than granite, it is probably as hard to cut and finish, and takes similar tools. As agreements for cutting and dressing the stone must be made on a granite

basis, it naturally follows that it takes the name granite which is exceedingly unfortunate as the nomenclature of building stones is sufficiently confusing already. The stone is properly a quartzite or quartzitic sandstone, terms while not common in the market are not unknown, or difficult of interpretation, and the use of them will avoid widening the use of the word granite which already includes (in the stone market) a great many varieties of rock.

Description.— Like all quartzites, it is very hard compared with common sandstone. Quartzite differs from common sandstone in having a greater proportion of siliceous cement, which being harder than the clay or iron oxide cement, binds the grains of sand more firmly together. It may grade imperceptibly from the friable sandstone on the one hand into compact quartz in which the original grains are no longer perceptible on the other. The quartzite of the Mauch Chunk formation shows the separate grains quite distinctly, but they are very firmly bound together and there is nothing friable or crumbling about it. In some cases the hardness is due to a carbonate, presumably calcite, cement which appears in considerable quantities in the microscopic examination. The stone is not quite so hard as the Sioux Falls, Dakota, quartzite, much used in the western markets, and apparently about equal in hardness to the Potsdam stone from Potsdam, New York. Its hardness is indicated by its great crushing strength which surpasses that of many of the granites.

The stone is distinctly stratified occurring in layers from a few inches to several feet in thickness. In most places the upper layers and face of the stone at the outcrop are in thin layers which in almost every instance thicken towards the interior of the bed. In some places the thin layers extend to a greater depth than in other localities close by, and are in all cases the result of the weathering influences opening the incipient bedding seams. As these thin layers make excellent flagstone they are a desirable feature much sought after.

In many places the rock contains false bedding quite pronounced, but unlike false bedding in many rocks, it is so regular and even that for quarrying purposes it takes the place of true bedding and in several places the parting seams in the flagstone are on the false bedding planes which are as regular and produce as nice flags as the true bedding, but naturally have more waste in working them. (See Fig. 1, p. 17.)

The color is various shades of red, but with the exception of a faint banding in many places it is generally uniform at any one locality. It is in general lighter and brighter than the average brownstone, although it has a deep brownish red color in places. The faint *banding* is very common, the bands running with the grain or bed *of the rock, which is* sometimes with the true bedding of the rock, *but in many places* with the false bedding.

Chemical composition of the Mauch Chunk Red Stone—The stone is very highly siliceous, having a higher percentage of silica than the average sandstone and about equal to the average quartzite, as may be seen by comparing the analyses in the table on page 13. The two analyses given below are the only ones that have been made as far as could be ascertained. The first, made at Cornell University, N. Y., is of the Laurel Run Red Stone, from the quarry managed at the time by Gen. P. A. Oliver, now worked by J. A. Schmitt. The other is the White Haven stone, "Red Granite," from Mr. Daneker's quarries, made in the Crane Iron Company's laboratory:

Analysis of the Laurel Run Red Stone.

Silica (SiO^2),	94.00
Iron oxide (Fe^2O^3),	1.98
Lime (CaO),	1.19
Magnesia (MgO),	1.00
Volatile matter, water and carbonic acid,	1.92
Alumina and manganese,	
Total,	100.00

Analysis of red quartzite ("red granite") from John A. Daneker's quarry, White Haven, Pennsylvania.

Silica (SiO^2),	90.360
Protoxide of iron (FeO),*	1.147
Alumina (Al^2O^3),	2.173
Metallic iron (Fe),	.803
Lime (CaO),	2.
Magnesia (MgO),	Trace.

Physical tests: weight, absorption and strength†—The stone has a specific gravity of 2.656, equal to a weight of 166 pounds per cubic foot. This represents an average of 25 samples, which range from 2.586 (the only one below 2.6), the lowest to 2.723, the highest, 20 of the 25 being between 2.6 and 2.7, one below 2.6 and four above 2.7.

The ratio of absorption after immersion in water 20 days is less than one per cent. For the stone in its natural condition the rate is .11 per cent., for artificially dried stone it is .365 per cent., which is far below the average of sandstone.

Tests on the Laurel Run Red stone at Cornell on 12 two-inch cubes gave an average crushing strength of 17,640 pounds per square inch ranging from 14,200, the lowest, to 23,600, the highest. One three-inch cube, and two four-inch cubes were not broken under a pressure of 50,000 pounds.

*So given in the copy of the analysis, apparently a mistake for peroxide, as indicated both by percentage of metallic iron and the red color of the stone.

†Data under this head almost entirely from tests made at Cornell University.

Thus it will be noticed by comparing with other stones on page 30, that this is much higher than any of the common sandstones and much like that for quartzites and quartzitic sandstones.

Its transverse strength in which this stone surpasses all common sandstones, and which is a necessary property in such positions as sills, lintels, facings and steps, is shown in the following tests made at Cornell, on the Laurel Run Red Stone.

Deflection test on Laurel Run Red Stone.

No.	200 lbs.	400	600	800	1,000	1,200	1,400	1,600
2	0.015	0.025	0.033	0.042	0.063	0.073	0.088	Broken.

No.	900	1,100	1,300	1,500	1,700	1,900	2,100	2,500
3	0.010	0.022	0.046	0.052	0.066	0.072	0.098	0.148

No.	2,700	2,900	3,100	3,700	3,900	4,100	4,300	Broken.
3	0.156	0.160	0.208	0.276	0.294	0.312	0.306	

Shearing test on Laurel Run Red Stone.

Block 2.00 x 2.00 □, in double shear over area of 4.5 sq. in.

Load, . .	500	1,000	1,500	2,000	2,500	3,000	3 500
Def., . . .	0.48	.078	.100	.114	.132	.156	.188

Load, . .	4.000	4,500	5,000	5,500	6,000	6,500	7,000	7,500
Def., . .	.198	.214	.232	.240	.256	.276	.286	.304

Frost test on Laurel Run Red Stone.

(Test by hot immersion.)

No.	Weight cold.	Weight after immersion.	Loss in weight.	Per cent.
1	131.826	131.670	0.156	0.12
2	145.649	145.515	0.154	0.11
3	118.348	118.003	0.346	0.29
4	144.360	143.985	0.375	0.26

Frost test on Laurel Run Red Stone.

(Test by Brard's Method.)

No.	Weight in air.	Weight dried 1 day.	Weight dried 3 days.	Loss.	Per cent.
1	125.748	125.831	125 670	0.018	0 06
2	96.314	96.371	96.165	0.149	0.15

NOTE.—In the test by hot immersion, Nos. 3 and 4 had been previously saturated with water, so that the test was especially severe and represented a maximum effect.

Absorption tests on Laurel Run Red Stone.

No.	Weight in air.	Weight wet.	After one day.	Two days.	Twenty days.	Loss.	Per cent.
1 . .	106.224	106.283	106 512	106.485	106.596	0.313	.29
2. . .	123.296	123.370	123.836	123.874	124.173	0.803	.65
3. . .	144.281	144.376	144.614	144.640	144.670	0.294	.21
4. . .	126.883	126 946	127.226	127.291	127 341	0.395	.31
5. . .	136 294	136.376	136.475	136.465	136.520	0 144	.10
6. . .	94.580	94.650	94.686	94 765	94.740	0 090	.09
7. . .	118.600	118.480	118.660	118.690	118.675	0.195	.16
8. . .	114.590	114.655	114.792	114 832	114.813	0.128	.11

NOTE.—Nos. 1, 2, 3 and 4 were artificially dried before testing. Nos. 5, 6, 7 and 8 were just as received.

Compression tests on Laurel Run Red Stone.

Number.	Deflect at 0 lbs.	1,000 lbs.	2,000 lbs.	3.000 lbs.	5,000 lbs.
13.	0.000	. . . . .	. . . . .	0 003	0.011
15.	0.000	0 051	. . . . .	0.051	0.029

Number.	10.000	15,000	20.000	25.000	30,000	35,000	40,000	45,000	50.000
13	0.028	0.020	0.920	0.034	0.012	0.011	0.026	0.019	0 028
15.	0 021	0.047	0.055	0 065	0.069	0.055	0.045	0.057	0 075

Crushing tests on Laurel Run Red Stone.

Number.	Area.	Crushing load.	Load per square inch.	Remarks.
1, ...	2.20	44 500	20,200	Bedded in wood.
2.	2.12	35.400	16.700	" plaster.
3.	2.07	33,300	16.000	" "
4.	1.99	47.500	23.600	" "
5.	2.22	37.000	16.700	" "
6.	2.10	35.000	17.000	" "
7.	2.22	31.000	14.200	" "
8.	2 25	40.000	15,500	" "
9.	2.25	48,600	21,500	" "
10.	2 22	34.000	15.000	" "
11.	2.25	47.500	21,000	Broken along bed.
12.	2 25	32,500	14.400	Broken along bed.
13.	4.45	50.000	. . . . .	Not broken.
14.	4.20	50.000	. . . . .	Not broken.
15.	3.43	50,000	. . . . .	Not broken.

Mean = 17640 lbs. per sq in.

Flexure tests on Laurel Run Red Stone.

Number.	Area of section.	Between supports.	Breaking load.
1, ...	2 03 (b) x 1.50 (h)	7 inch.	1 600 lbs.
2.	1.99 x 1 47	7 inch	1.400 lbs.
3.	2.06 x 2.05	5 inch.	4,500 lbs.

In the assay laboratory at State College several samples from the Laurel Run and the White Haven quarries were tested in the furnace to ascertain their fire-resisting properties. They were first heated to 700 degrees Fah. then 1,150 degrees and then 1,600 degrees and some even higher. Some were cooled in air and some thrown in

cold water. Only one of the specimens was cracked, the others showing no injury in the texture, but those at the high temperature, 1,600, changed color perceptibly, the rather bright red turning to a pale, brownish red, the tests proving that if not absolutely fire proof the stone stands the fire remarkably well, and is entitled to rank among the fire proof stones.

Microscopic character of the Mauch Chunk Red Stone.—The accompanying figure (fig. 8) shows some of the different types of tex-

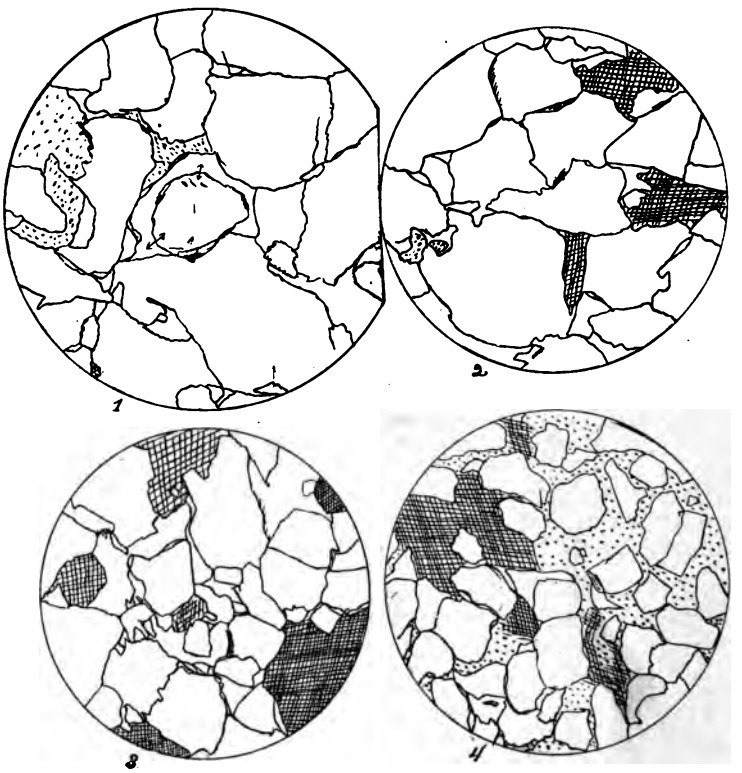


Fig. 8.—Micro-drawings—enlarged 44 diameters—of the Mauch Chunk red stone. Cross-lined areas clay with finely granular quartz, dotted areas calcite, clear areas quartz. Typical quartzite grain in middle No. 1. No. 4, an exceptional calcareous area. All show the interlocking of the quartz grains.

ture taken from rocks of different quarries, but the texture is by no means uniform at any one locality or at any one quarry, or in fact in a single specimen, (See also No. 2 on Plate 1.) No. 1 on figure 8 is from the Laurel Run quarries and shows a typical quartzite grain in the midst of the section, with an old sand grain in the interior surrounded by secondary quartz oriented with the enclosed grain. Secondary quartz is shown elsewhere in the figure and the dotted areas are carbonate (presumably calcite) cement, which makes a rock nearly as hard as the quartz cement. No. 2 is from the same quarry *and shows some clay* in the interstices possibly from feldspar decay-

ed in place. No. 3 is from Daneker's White Haven quarries and shows a greater percentage of clay, but still retaining the quartzite character by the interlocking of the quartz grains with secondary quartz. No. 4 is from Cooper's quarry and shows the predominance of the calcite cement making really a calcareous sandstone. However, similar calcareous areas may be found in the sections from the other quarries.

Durability.—The stone if properly selected is one of the most durable ones in the State. This is indicated by 1. The chemical analysis which shows it to be nearly all quartz, one of the most durable of minerals. 2. Its texture, which is close-grained, compact, and almost wholly non-absorbant. 3. The outcrops which frequently form bold ledges, even hills of prominence through the region in which it occurs. 4. The glacial boulders which over this area are in many places nearly all this red quartzite and almost invariably have a hard, smooth surface with no evidence of disintegration after their hard freezing and many centuries of exposure.

Artificial tests made in the Cornell laboratory as shown on the preceding pages, also indicate great durability; four samples in the hot immersion test, showing a loss less than a quarter of one per cent. 0.12, 0.11, 0.29 and 0.26 respectively. Brard's frost test showed a loss even less two samples giving 0.06 and 0.15 per cent.

Uses and adaptability.—The stone has been used for buildings, both facings and trimmings, pavements both foot and street, for bridges, retaining walls and foundations. The flagging forms an important part of the product and is much sought after. A large part of the product goes into Belgian blocks for paving streets. It is said to be superior to granite in this respect.

It is not a first class stone for all varieties of building work. Its great hardness does not adapt it to any class of work that requires much cutting or dressing. However, it is claimed by workmen that this difficulty disappears in part with familiarity with the stone.* The even regular bedding and the ease with which the stone can be chipped, along with the smooth compact texture and pleasing color adapt it to rock-faced ashlar, either coursed or uncoursed. It is superior to many other building stones in having such a hard close texture that dust and vegetation do not disfigure it. The hard,

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Wilkesbarre, Pa., April 4th, 1890.

*In all my experience as a stone-cutter, I have not met with a stone so hard as the Laurel Run Red Stone, that I can manage as easily as I can the Laurel Run Red Stone. A man unacquainted with the stone will say, on first attempt to cut it, that it is an unpleasant stone to cut. This impression will, after a few days or weeks experience be changed, and he will notice that after his days work is done, he is not so tired as he was when he cut the soft sand stones or granite. It requires a peculiar manipulation of the tools, and when once acquired, it is not hard work. I like to cut Red Stone, I have been cutting it for seven years or more.

Yours truly,
JAMES TEMPLETON.

rather glassy appearance of the stone is against its universal use as a building stone even though it could be easily wrought. Some of the accompanying illustrations show the architectural appearance of the stone. While not an ideal building stone, it is a very good one, and will likely be used in considerable quantities for that purpose. It will never have an extensive use because of the opposition from the stone-cutters.

It is best adapted to street work and should be used more extensively for that purpose. It is admirably adapted to this work for curbing, crossings, Belgian blocks, flagging or crushed stone. It furnishes an almost ideal flag stone where it occurs in thin sheets, being hard, strong, and not breaking easily, and would practically never wear out or wear as smooth as limestone or granite, nor is it so readily soiled or discolored as a lighter colored stone. For Belgian blocks it is eminently suited, being very hard, yet easily chipped into shape, does not wear rapidly or wear smooth.

Methods of quarrying.—The work throughout the area is largely done by hand. Holes are drilled by hand and charged with powder, blasting off large blocks of the stone, which are broken up with heavy hammers and trimmed with hand hammers into Belgian blocks of standard size or cut by hand into the proper form for curbing or dimension stone. Most of the derricks are of hand power, only a few horse power and but one steam power, although Mr. Daneker at White Haven is daily (Sept., '96) expecting steam hoist and steam drill. He also contemplates a saw mill to be run by water power to saw the stone into shape. The steam drill and steam hoist are used in the Laurel Run quarries in connection with the Knox blasting system.

Distribution.—The distribution of the Mauch Chunk formation in the State is shown in part on the accompanying map (frontispiece.) Besides the area on the map this formation has quite an extended linear out crop through the north-central and the southwest part of the State, but so far as known to the writer there is, with probably one exception, no sandstone or quartzite of commercial value in this part of the area. In fact in only a small part of the area shown is the quartzite known to occur, as the greater part of the formation is of red shale. So far as known the only places it has been quarried are Mocanaqua; the Elbow, near Mt. Park, Wilkes-Barre; Laurel Run; and along the Lehigh valley from two miles or more above White Haven to Hickory Creek several miles below White Haven. A quarry near Rockwood, Somerset county, Pa., may be in this formation.

Local details of the Mauch Chunk Red Stone.

White Haven.—While the red quartzite occurs abundantly in the village of White Haven, the regular quarries of the stone are some distance from the town, both south and north, in the Lehigh valley.

Reiser and Doland's quarry.

Cooper's flag-stone quarry.

Quarries in the Mauch Chunk red formation along the Lehigh river below White Haven.

The largest producing quarries are about two miles north of the town and belong to John Daneker, who has quarried stone here since 1873. For 17 years he wagoned the product to White Haven and shipped from there by railroad. In 1890, he constructed a short branch railway from the Lehigh Valley railroad to one of his quarries, and later from the Central Railroad of New Jersey to the other, and can now ship by rail direct from his quarries by either railroad. He shipped more stone in 1890, the first year he had the railway in the quarry, than in all the previous years together. Heretofore the work has been done by hand, but a steam drill and a steam hoist has been ordered and daily expected (September, 1896), after which the stone can be handled more rapidly and presumably will be worked more extensively. He contemplates adding a saw mill, to be run by water power on the creek that passes the quarry. It is very doubtful if a stone as hard as this can be sawed with profit.

The work so far has been largely surface work, none of the openings penetrating to any depth, but scattered over a large area. They may be divided into two groups, one group being scattered along the west bank of the Lehigh river, and another along the east bank of a small creek nearly a mile from the river. Plate 25 shows views in these quarries. The ones on the creek bluff have been worked more extensively than the others. There were apparently at one time a number of openings along the low bluff, but they are now nearly all connected into a continuous opening, several hundred yards in length.

The workable stone varies in thickness from 15 to 30 feet along this bluff. The quality of the stone is superior towards the west end, where the covering is also the heaviest. The inferior quality of the stone towards the east end has caused that end to be abandoned.

Much of the flagstone has the parting on the cross-bedding. The layers vary somewhat in character in different places. What is good stone in one place is too shelly and seamy in another part of the layer to be valuable. In most places the stone is sufficiently thin bedded for flagging near the surface, the bedding planes disappearing away from the outcrop toward the interior of the bed. This is probably the chief reason why so much of the work both here and elsewhere is confined to the surface, as the heavy bedded and massive stone is very hard to work by hand.

In some places the good marketable stone appears at the surface, while in other places it is covered with glacial boulders, sand and gravel, to a depth varying from a few inches to three or four feet. Frequently from two to six feet at the top of the bed will be shelly or "wild" and thrown out with the waste, but in some places the shelly stone is wholly lacking.

The quarries on the river show a much greater thickness of stone

than the other quarries, but they have been more recently opened, and have not been worked so extensively. In no single opening was a thickness greater than 50 feet observed, but the different openings are on different layers, so that the total thickness shown is probably 200 feet or more, with more or less intercalary shale. The strata dip to the north about 10 degrees, so that the underlying layers are met in going south along the railway track. Underneath the stone in the most southern opening is a heavy bed of red shale, which contains conglomerate in places, and north of the upper opening hard stone outcrops in the overlying layers at least as far as the bend of the river, a half mile or more above.

A section of the face at the north opening shows:

4 to 6 feet of glacial material, sand and boulders.

20 feet of red stone, free from bands, nearly uniform in color.

30 feet of faintly striped or banded red stone; some cross grain.

5 feet red shale.

Near the south end a section shows:

10 feet weathered shaly red quartzite.

12 feet red quartzite with numerous seams.

18 feet clean solid red quartzite, with remarkably smooth joint seams.

12 feet solid red quartzite.

8 inches striped quartzite, red gray and dark bands.

The striped layers at the base appear to be a gradation between shale and the quartzite, and while the freshly exposed stone in the quarry appears to be quite hard and firm, it is not liable to prove as durable as the single colored stone.

Near the south end of the ledge there are great numbers of clear quartz crystals, which form a thick coating along the seams. Most of these crystals are small, but some are a half inch or more in diameter. They are almost as clear as those from Herkiomer county, N. Y. So far as observed by the writer, this is the only locality in the Mauch Chunk area where the quartz crystals occur in any considerable number.

There is a vast quantity of this red stone available both in these openings along the river and in the other openings described above, and everything suggests that the stone industry here is but in its infancy. While good building stone is available it is probable that it will always be secondary to the production of Belgian blocks, flagging, curbing and broken stone work. The working of the stone is greatly facilitated by the even parallel joint seams. Mr. Daneker is now filling a large order for paving blocks to Elmira, N. Y.

John Redington and Company's quarry.—Redington & Company's quarry is a half mile below White Haven, near the top of the hill *on the east side of* the Lehigh river, near the Lehigh Valley railroad,

View of portion of the creek quarry looking south.

View of portion of the creek quarry looking southeast.

and a short distance north of Tannery station. The quarry has a face of 25 to 35 feet of red quartzite, overlain by a few feet of glacial material and underlain by red shale. In places there is a thickness of a few inches to two or three feet of loose shelly rock at the top, while at other places the rock is sound to the top. There is considerable cross grain running in different directions in different parts of the bed.

Some flagstone has been obtained near the surface, but none in the interior of the bed where the layers are heavier. Nearly all the product of the quarry is used for Belgian blocks. At the present time (October, 1896), they are shipping blocks to Wilkes-Barre on an order for fifty car loads.

The quarry has been operated by this company for about two years and was run by other parties in a desultory way for about six years previously. The company is not doing a large business, but apparently a profitable one. The quarry is kept clean and in good shape.

On the west side of the river opposite Redington & Co's. quarry, is a quarry opening, now idle, said to belong in part to Mr. Fox and in part to Mr. Kennedy.

Cooper Brother's quarry.—The Cooper Brothers' quarry is on the west side of the Lehigh river, below the Tannery. Unlike the other quarries, it is not on a bluff, but on the nearly level top of the hill, about one-fourth mile back from the river and the railroad.

The top of the hill is nearly level and the strata are here nearly horizontal. The hill has been planed off by the glaciers, glacial striae showing in a number of places bearing South 5 degrees West. There is in most places a thin coating of glacial material, varying from a few inches to a few feet in thickness, consisting of sand and a great many slabs of the red quartzite overlying the red stone in place.

This is more distinctly a flagstone quarry than any of the others in the vicinity, and the product of the quarry is almost entirely flagstone. The bottom view in Plate 24 shows the flagstone character of the stone. The stone has been worked to a depth of about 12 feet, and comes out in small regular flags from two to six inches thick. In some places near the surface the flags are separate, and it is only necessary to pry them up and break them into the required dimensions; in other places the seams are not open, and it is necessary to wedge the slabs loose from the bed. Mr. Cooper says they have raised flags from 25 to 35 feet long, but most of it is in smaller dimensions. Some of the slabs show faint ripple marks. The quarry has been operated by the Cooper Brothers since 1892, and while operated on a small scale, the product has been increasing each year since the quarry started.

In a shallow ravine about 100 yards south of the flagstone quarry,

there is a solid ledge of the quartzite exposed from 20 to 30 feet thick, from which they have quarried some stone; more of the work done here, however, has been on the boulders which have broken loose from the ledge. Some of this stone is of a deeper red than the flagstone.

Reiser and Doland's quarry.—Still further down the Lehigh Valley, below Penn Haven Junction, on the Central Railroad of New Jersey, is another red stone quarry operated by Reiser & Doland, of Wilkes-Barre. The product of the quarry has been increasing in value since it was first opened in 1894.

The product of this quarry is about evenly divided between flagstone and building stone, no blocks having been made so far. The stone is nearly all shipped to Wilkes-Barre where it is used for pavements, steps, platforms, trimmings for brick buildings, foundations and retaining walls.

The face of the quarry runs nearly north and south, and parallel with and along the outcropping ledges of the strata, with dip N. 10 to 15 degrees. The thickness of the stone worked is about 15 to 20 feet. In the present opening there is more flagstone at the south end where the work is nearer the outcrop, in places the flagstones being only two or three inches thick, and at the north end where the opening is deeper, the rock is heavier bedded, and for the most part a quite uniform chocolate color, almost free from the banding so common in many places. Shelly quartzite and shale outcrop in large quantities underneath the bed worked in the quarry. The upper view on Plate 24 is taken from near the south end of the quarry, looking north and down along the face of the quarry with Lehigh river in the distance.

Laurel Run Red Stone quarries.—The Laurel Run Red Stone quarries are at Oliver's Mills on the Central Railroad of New Jersey, about ten miles south of Wilkes-Barre. The quarries are along the ridge on the northwest side of Laurel Run, a branch from the railroad extending into the quarries 300 yards or more. The stone has been quarried along the face of the bluff for nearly a half mile. The northeast end belonging to General Oliver runs in a northeast direction, and is now worked by John Schmitt, of Wilkes-Barre. The southwest end running S. 75 W., and belonging to the Hollenbach Coal Company and the Lehigh and Wilkes-Barre Coal Company, is not operated at present.

The stone belongs to the Mauch Chunk red formation, and is quite similar in its general character to the stone at White Haven. The tests given on page 94 are on stone from Olixer's quarries.

The dip of the strata is northwest or into the hill, so that the thickness of the stripping increases rapidly as the stone is worked back into the hill, which accounts for the great length of the quarry and

Quarry face in John Schmitt's quarry.

Part of face in Oliver's quarry showing the cross bedding.

Views in the Laurel Run red stone quarries. Showing structural features.

the narrowness of it because as soon as the thickness of the stripping is thought to be too great to be removed with profit, operations are suspended in that direction and extended laterally. The thickness of the layers quarried is about 20 to 25 feet. The overlying material consists of a softer, crumbling rock overlain in turn by glacial debris and the underlying rock is concealed by debris.

The true bedding of the rock is very faint, scarcely discernible in some places, but the false bedding is in most places rather pronounced, shown generally by a banding along the false bedding planes, and in some places a cleavage or parting on the false bedding, some flagstone being formed in that way. The false bedding in most places is inclined east of north, but in a few places it dips in different directions, as shown on the accompanying photograph Plate 26, and drawing in Fig. 1, page 17.

Flagstone occurs in nearly all places on the outcrop, the effect of exposure apparently being to open the bedding (in most instances false-bedding) planes. As the stone is quarried back from the outcrop, the seams become less numerous and finally disappear, and the stone becomes solid and apparently harder. It is very difficult to drill and cut, but where the grain is straight it works to fairly good advantage, as it splits straight and easily. When the stone is massive and cross-grained, it is quite difficult to work, as the fracture is liable to branch off on the false bedding in unexpected places.

Most of the stone quarried here is used for building purposes in Wilkes-Barre, some of the finer buildings constructed of it being the St. Nicholas German Catholic church (see Plate 4), First Presbyterian church, Baptist Chapel and numerous residences. (See list on page 40.) It has been used in large quantities for foundations and retaining walls in Wilkes-Barre. Some stone was shipped to Philadelphia by General Oliver, but the venture did not prove profitable, and was not repeated. Much of the broken stone and waste is crushed with a steam rock crusher and used for concrete. The capacity of the crusher is about six car loads per day. The stone is admirably adapted for this purpose, the particles being so hard that they will resist wear where subject to it, and are equally proof against attack by acids and corroding agencies.

The stone will no doubt continue to have a limited use for building purposes, but it will never be extensive, because of the difficulty in dressing it, and the opposition from the stone-cutters. It is well adapted to rock-face ashlar in combination with other building stones. No more durable stone could be obtained for bridge piers. Its hardness and durability make it an admirable stone for flagging, curbing and paving. The points in favor of its more extended use

are 1, great durability; 2, its great strength; 3, its beautiful color; 4, large and small dimensions; 5, convenient to the railway. While its disadvantages are 1, hardness; 2, cross-grain; 3, heavy stripping; 4, limited dumping ground because of the railway running along the side of the steep hill just below the quarry.

The Elbow.—At the Elbow on the Central Railroad of New Jersey, between Laurel Run and Mt. Park, considerable red stone has been quarried, but the quarries are not now in operation. There is one opening on the lower (east) side of the railroad on a steep hillside overlooking the creek. The strata dip from 12 to 20 degrees west of north, thus crossing the track. There has been very little rock removed from the upper side of the railway on account of there being no dumping ground, and the loose rock in quarrying rolling on the track and interfering with railway travel. The thickness of the stone quarried varies from 15 to 25 feet, with about the same thickness of stripping. There has been some flagstone and some heavier stone removed which shows considerable cross-bedding in places. No particulars are at hand as to the length of time this quarry was open, or of the use made of the stone.

Across the ravine about 150 yards east of the Elbow there is another opening in the Mauch Chunk red quartzite that has been worked over an area of about 20 or 25 yards square, with a maximum depth of about 30 feet. There is a thickness of about 10 to 20 feet, from which nice flagstone two to four inches thick was obtained, the beds of the flagging being faintly ripple marked in places. The upper part of the rock exposed at the opening is full of seams and cracks, and is useless as building stone. Part of that in the lower part of the bed is much cross-grained and cannot be worked to advantage, so that there is a great deal of waste.

There is another small opening, belonging to Mr. Parsons about 100 yards east of the one last mentioned which has been worked by hand on a small scale for a year or more. A hand derrick has recently been put up and flagstone is being removed.

The red quartzite outcrops in many other places in the mountains south of Wilkes-Barre, but so far as could be ascertained it is not worked at any other point. Mr. Joseph Hendler who has a large conglomerate quarry about two miles east of the Elbow, claims to have a very promising outcrop of red quartzite easily accessible by railroad.

Mocanaqua —A half mile above Mocanaqua Station, on the Pennsylvania railroad, opposite Shickshinny, is a quarry in the Mauch Chunk red quartzite that is idle at present. It is on the south side of the north branch of the Susquehanna river, close to the railroad—

too close in fact, as it leaves no room for a dump. The hill is here very steep, capped with the coarse Pottsville conglomerate, and the quartzite forms a bold outcrop, but not in the most desirable positions for quarrying, as the steep bluff prevents working any but the surface stone, and the railroad and river along the base interfere with dumping the waste material. The stone varies greatly in character, thus a layer that is good, solid flagstone in one place will be quite shaly or be part of a massive ledge only a few yards away. Near the east end of the quarry opening a section shows 25 feet of rather massive quartzite, but shelly on the surface, underlain by 10 to 12 feet of solid massive quartzite, underlain by 12 feet of banded quartzite, that furnishes flagstones on the outcrop.

Good stone in sufficient quantities for local usage could be obtained here at moderate expense. While the stone is very hard and in heavy layers the greater part of it has an easy cleavage parallel with the bedding. Local workmen state that the stone is not difficult to work.

In the vicinity of Mocanaqua, Wilkes-Barre and elsewhere throughout the anthracite coal region the hard, massive, Pottsville conglomerate has been quarried for use in bridge piers and other heavy masonry.

PART III. BROWNSTONE IN THE UNITED STATES OUTSIDE OF PENNSYLVANIA.

Pennsylvania has a larger area of the New Red formation than any other one of the eastern states, and probably has as many or more brownstone quarries, but most of the openings are small, of only local importance, and it is not the leading state in the value of brownstone produced.

In the total value of sandstones produced Pennsylvania ranks second in the Union, Ohio standing far in the lead. But brownstones while forming a considerable part do not include all the sandstones of the State. There is much gray and buff stone in the western and central portions. Connecticut, with but four quarries, ranks first in the production of brownstone, having the oldest and largest brownstone quarries in the United States. The brownstone product of New Jersey is probably nearly equal to that of Pennsylvania.

The output of New York, Wisconsin and Michigan forms an important part of the total product.

Fig. 9.—Showing location of brownstone quarries in the United States.

As the stone from these different quarries meet in competition in the markets, it is thought advisable to give a brief description of them in this report.*

Colorado.

Several shades of brownstone said to be of good quality and well adapted to building purposes occur at different points in Colorado in the "Red Beds" (Lower Trias).

Quarries have been opened at Manitou, Bellevue, Stout Arkins, and Lyons, but no particulars are at hand as to whether any of these are or are not in operation at present.†

Connecticut.

The brownstone quarries at Portland, Connecticut, are the oldest, largest and best known quarries in the United States. So extensive has been the use of this stone that in many places the terms brownstone, Portland and Connecticut stone have been used as synonymous terms.

*The Connecticut quarries, many of the New Jersey and the Ohio ones, and all of the Indiana quarries, have been visited by the writer; the descriptions of the others have been obtained by personal correspondence and interviews with the quarrymen, dealers and others, and from census reports and such other sources of information as could be found. The States are arranged in order alphabetically.

†A *brief* description of the above localities is given by Merrill in "Stones for *Building and Decoration*," New York, 1895.

The miles of brownstone fronts in New York and other eastern cities attest its architectural value and beauty. The many scaling and disintegrating fronts equally well illustrate its misuse.

The oldest and largest quarries are at Portland on the east bank of the Connecticut river, opposite Middletown, and near the center of the state, where stone has been quarried for 200 years or more. The oldest authentic record of the operation of these quarries is a mention of them in the record of the town council at Middletown, 1665. So far as known they have been operated continuously since that date.

In 1852 a quarry was opened at Cromwell, on the west side of the river, two miles above Portland, and another in 1886, both of which are now in active operation.

The stone at both places is regularly stratified, the strata having a gentle dip of a few degrees to the west. The separate beds have a thickness varying from a few inches to ten or twelve feet, in a few places much more.

The entire thickness of the stone is not known, but it is known to be more than 500 feet in one place. The Middlesex Quarry Company quarried to a depth of 200 feet and drilled with a core drill 312 feet more, giving a total of 512 feet, without any perceptible change in the character of the rock. How much deeper it is, is not known. None of the openings are more than 250 feet in depth, the companies finding it more profitable to strip a new area than to quarry deeper than that. Dana, in his manual of geology, states that an artesian boring was carried down 4,000 feet at New Haven through porous sandstone.

The stone varies slightly in color and considerably in texture. Layers of good, fine-grained brownstone alternate with layers of coarse conglomerate, fine conglomerate and streaks of shale. The conglomerate is not limited to any one part of the quarry, but is more abundant towards the top than at the bottom. Much of the coarse stone goes into the waste, but that with smaller pebbles is sold as second and third class stone. More than half the stone is thrown out as waste.

The analyses of the stone show it to be less highly siliceous than many other sandstones, and from the standpoint of durability alone a lower percentage of alumina might be desired, in so far as it absorbs moisture, thus hastening decay in the scaling, cracking and disintegration. This is partly balanced by the fact that clay is a much softer cement than silica, and hence the stone is more easily cut and dressed.

Analyses of Connecticut Brownstone.

	Portland.	Cromwell.
Silica (SiO^2),	70.11	70.84
Alumina (Al^2O^3),	13.49	13.15
Iron oxide (Fe^2O^3),	4.85	2.48
Lime (CaO),	2.39	3.09
Magnesia (MgO),	1.44	Trace.
Potash (K^2O),		3.30
Soda (Na^2O),	7.37	5.43
Loss,		1.01
Total,	100.00	100.00

Mineralogically it is made up of quartz, feldspar and mica—granitic detritus. The mica is present throughout the bed, occurring even in the coarse conglomerate, but more abundantly in the thinly laminated part of the bed. The stone has a dark brown color, remarkably uniform throughout all the quarries.

There are now three companies at Portland. The Brainard Company and the Shaler and Hall Company combined this year into the Brainard, Shaler & Hall Company, which operates all the quarries formerly run by the two companies. The Shaler and Hall Company has been in existence since 1788, owning the lower or south quarry at Portland. The Brainard Company started in 1812, under the name of E. and S. Brainard, changing to E. and S. Brainard & Company, later to Brainard & Company, and finally in 1879 to the Brainard Quarry Company, which it remained until the change above noted this year.

The Middlesex Quarry Company was organized in 1841 by the union of the Patten and Russell and the original Shaler and Hall quarry. They operate the upper or north opening which covers about 30 acres, and is worked in several different places.

The other company at Portland is the Connecticut Steam Brown Stone Company, which has no quarry, but operates a large steam mill where stone from the other quarries is cut and dressed for position in the building before shipping. This was established in 1884, and one wonders on seeing the large amount of stone that annually passes through this mill, why such a mill was not operated there long before that time.

There are three companies at Cromwell, and as at Portland two quarry companies and one mill company. The Connecticut Free Stone Quarry Company opened its quarry in 1852, and with the exception of 16 years, when it was leased to the Portland quarries, it has been in operation ever since.

The New England Brownstone Company has been in operation since 1886, and has done an extensive business.

The Middlesex Steam Brownstone Company has a mill on the premises of the New England Brownstone Company, in which the stone is prepared for its place in the buildings. The stone at Cromwell is very similar to that at Portland in character. There is a heavier bed of glacial material overlying it, and as far as one can judge from a hasty inspection of the quarry walls, there is more waste than in the Portland quarries.

The quarries, yards and mills at both Portland and Cromwell are equipped with modern machinery and appliances. The drilling is done almost entirely with steam drills and the steam channeler is used to some extent, but the presence of numerous bedding seams enables them to loosen the stone much more cheaply with the Knox blasting system, which is used in all the quarries. The channelers are used for cutting out corners, cross cutting at the ends, etc.

Formerly the stone was dragged from the quarry to the boat landing by oxen, at one time as many as 200 cattle being in use for this purpose. Steam has almost entirely replaced the cattle, two yoke at the Cromwell quarry being all there are in use at the present time (October, 1896). The stone is now lifted from the bottom of the quarry with steam hoists on large cranes and placed on the railroad car, frequently 200 feet or more above the quarry floor. The edge of the quarry is studded with these large cranes, capable of lifting a car load of stone in a few minutes. There are several large locomotive cranes moving on the track about the yards loading and unloading stone. There is a railway switch from the New York, New Haven and Hartford railroad to each of the quarries, and the Cromwell quarries also have connection with the New England railroad, but the greater part of the stone is shipped by boat on the Connecticut river from docks near each of the quarries.

Prices of the Connecticut brownstone ranged from 50 cents per cubic foot in 1844 to $1.26 in 1874, and has since dropped until at the present time the price is 95 cents for first class brownstone. The prices for second grade and inferior stone is much lower. The annual production of stone of the first quality during prosperous years varies from 850,000 to 1,000,000 cubic feet; of the coarser, cheaper grades, about twice that amount is produced. During the last two years the value of the output has been below $400,000 annually.

The Connecticut brownstone has been extensively used in all the eastern cities, especially those along the seaboard, New York naturally being the largest consumer, where some of the most elegant residences and public buildings are constructed of it. In smaller quantities it has been shipped all over the United States and even to Canada. Senator Flood's mansion, on Nob Hill, in San Francisco,

is of stone from the Middlesex quarry, which was first sent by boat to Newark, where it was dressed and crated, reloaded and shipped by way of Cape Horn to San Francisco.

For many years these quarries were excessively prosperous, and with from 1,200 to 1,500 men at work, could not fill all the orders, but the financial dullness of the country and other causes have changed this condition, and they are now in active competition with other quarries for orders. Not only has the opening of many new quarries elsewhere lessened the trade, but the facilities for handling the stone have improved so that there is scarcely any limit to the amount of stone that could be put out on demand.*

INDIANA.†

Brownstone occurs in several localities in the Carboniferous sandstones of western Indiana. The stone has been quarried at Mansfield, Hillsboro, Greenhill, Judson, Portland Mills, Bloomfield and St. Anthony, but the only quarries now in active operation are those at St. Anthony.‡

Two defects found in the stone are lack of uniformity and the occurrence of iron blisters. While these injure much otherwise good stone, it nevertheless remains that there is a great deal of excellent brownstone not yet quarried in the vicinity of Mansfield, Bloomfield and St. Anthony. J. B. Lyne & Son operate a well equipped quarry at the latter place, having switch connection with the Louisville, Evansville and St. Louis railroad.

Quarries have been worked to considerable extent at Mansfield and Hillsboro, the latter on the Cleveland, Cincinnati, Chicago and St. Louis railroad (Big Four), and the former connected by short line with the Big Four at Carbon and the Vandalia line at Brazil. A quarry was opened at Portland Mills in 1895 from which a railway is contemplated to the Indianopolis, Decatur and Western Railroad, six miles distant.

The Indiana Brownstone is soft, especially when first quarried, and is not fit for paving or any use where subject to abrasion, but is well

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*References:

1. The Middletown Tribune, Middletown, Connecticut, Souvenir edition, 1896, by H. F. Donlan and E. F. Bigelow, contains illustrated article on the Brownstone quarries.
2. Stone, Volume IX, No. I, June, 1894. Copiously illustrated article by Burton H. Allbee.
3. Mineral Industry, New York, Vol. III, 1894, pages 510-513.
4. Mineral Industry, Vol. IV, 1895, pages 555-558.

Papers on the fossils and the geological relations of the stone are to be found in the scientific journals and proceedings by the score. See Bulletin 85, U. S. Geological Survey, for list.

†Carboniferous Sandstones of Western Indiana, by T. C. Hopkins, in Twentieth Annual Report of the State Geologist of Indiana, 1895, gives an illustrated description of the brownstones of the State, with maps of the area.

‡This stone which could be quarried with profit in some localities has here to *compete with* the famous Oolitic Limestone of Indiana on one side and the *Joliet and Lemont stone* on the other hand.

adapted to building purposes, being soft and easily worked, and at the same time exceedingly durable.

Maryland.

So far as known the only locality in Maryland where brownstone has been quarried for more than local usage, is near the mouth of Seneca creek, in Montgomery county. This stone is described by Merrill as of a light reddish brown color, even texture, and well adapted to all manner of building purposes and ornamental work, in fact he pronounced it one of the best of the Triassic brownstones. The Smithsonian Institute building erected in 1848 and 1854 from this stone shows, it is said, but few defects from weathering. In some portions of the rock there are numerous clay holes, but these may generally be avoided by careful selection. It could not be ascertained whether the quarries are now in operation or not, as two letters to the companies elicited no response.

Massachusetts.

The Triassic brownstone of the same age as the Portland stone, extends up the Connecticut valley as far as the northern boundary of Massachusetts, but so far as could be ascertained, the only place it has been quarried to any extent in the state is at East Longmeadow. The principal operators here are Norcross Bros., and James and Mara. Three other companies have been operating there in recent years, whether at the present time or not is not known. The quarries are located on the New England railroad between Springfield and Hartford, and within easy access of the Boston and Albany railroad.

The Norcross Bros. quarry three shades of stone, the trade names by which they are known being "Maynard," a bright red stone, "Kibbe," a dark red, and "Worcester," a brown. One or more of these shades no doubt occurs in the other quarries. No further information is at hand concerning the nature of the deposit or of the extent of the quarries. Analyses and tests of the stone are given in the tables on pages 13 and 30.*

Michigan.

Brown sandstone of the Potsdam formation occurs in considerable quantities along the shores of Lake Superior in Northern Michigan. It has been quarried at Marquette, Portage Entry and L'Anse. Letters of inquiry to the different companies said to be in operation there elicited responses from but two, the Portage Entry Quarries Co., who has quarries in the Portage Entry red stone and the Mar-

*References:
1. Stones for Building and Decoration, by G. P. Merrill.
2. Geology of Massachusetts, by C. H. Hitchcock.

quette brownstone, and the L'Anse Brownstone Company, with quarries at L'Anse, both companies having offices in Chicago.

At Portage Entry the stone is quarried quite extensively and shipped by boat to the different lake ports, and thence by rail to many of the cities throughout the United States. The stone is fairly well known in the eastern as well as the western markets.

The company reports about 10 feet of workable red stone overlain by 20 to 30 feet of rock. It is quarried by channeling machines, steam drills, and the use of the Knox blasting system. The quarries have been operated about 15 years. One variety of this stone as it appears in samples, has a brick red color, quite fine grain, and is rather soft, but not friable. So far as observed by the writer, it has no exact counterpart in the brownstones of this country outside of the Lake Superior region. It resembles closely some of the English stone that is imported into this country.

Another variety is that known as the "Raindrop Sandstone," which has a medium fine grain, light, brownish red color, mottled in places with gray. Analyses and tests of both varieties are given on page 13.

The L'Anse Brownstone Company operate quarries on the east shore of Keweenaw Bay, about two and one-half miles north of L'Anse, Baraga county, Michigan. The quarried stone is shipped both by rail and by boat. The stone in the sample furnished is a fine grained brownstone resembling the Connecticut stone, but having less mica, and (in the sample) free from pebbles.*

MINNESOTA

Red or brown stone has been quarried at New Ulm and various other points in the southwest part of Minnesota, and in larger quantities at Fond du Lac and vicinity, along the south shore of Lake Superior. The stone in the southwest part of the state is a quartzite similar to the well-known Sioux Falls stone, but said to be for the most part where it is worked in very thin layers. It appears to have little more than local usage.†

The stone at Fond du Lac is supposed to be of the same formation as that at New Ulm, and that further east at Marquette, in Michigan, that is, the Potsdam. It is said‡ to have in general a reddish brown color, variously marked with spots and stripes of lighter shade. It has occasional grains of quartz as large as a pea or even as large as

*References:
1. Stones for Building and Decoration, G. P. Merrill, New York, 1891, p. 264.
2. Report of the State Board of Geological Survey for the years 1891 and 1892, pp. 156 and 157.
3. A Sketch of the Geology of the Marquette and Keweenawan Districts, by M. E. Wadsworth, in Along the South Shore of Lake Superior, by Jul. Ralph.
4. The Sandstones of Lake Superior, by H. G. Rothwell, March Stone, 1894.

†The Stone Trade News, December 15, 1896, states that the red stone quarries at Jasper, Minnesota, employing about seventy-five men, shut down November 21 for the season.

‡*Geology of Minnesota*, Vol. I, p. 181.

a hen's egg, distributed through the lighter portion of it. However, a small portion is conglomeritic, and there is said to be a great abundance of stone of a good quality.

The stone consists about two-thirds of rounded and sub-angular grains of quartz and nine-tenths of the remainder feldspar, often crowded and darkened by ochre and ferrite, but sometimes white and occasionally a light green angular grain, apparently hornblende or augite. There are a few grains of black magnetite and a little calcite. (See tables for crushing tests and analyses.)

On the Great Northern and Eastern Minnesota Railway at Sandstone, on Kettle river, Pine county, is probably the largest and best equipped sandstone quarry in the state. It belongs to the Potsdam formation the same as the Fond du Lac, but is not properly classed as a brownstone, as it has a beautiful pink or salmon color. This is an exceedingly handsome stone, and the appearance of the stone in samples and the result of the test and analysis (see tables, pages 13 and 30), would indicate a stone of great durability. The quarries are operated by the Minnesota Sandstone Company, Minneapolis, and are said to be well equipped with modern machinery, and the stone mill fitted for work of all kinds.*

New Jersey.

The Brownstone quarries of New Jersey are the nearest competitors of those of Pennsylvania, and as such are of considerable interest.

The New Red formation continues in a northeast direction from the Delaware river, entirely through the state of New Jersey to the Hudson river in the state of New York. Brownstones suitable for building purposes have been quarried at a great many different places along the area. Some of these quarries have been in operation for many years, a number have been abandoned, some temporarily, some permanently.

The most productive quarries at present are those at Avondale, and those at Stockton (Prallsville). There are quarries at Newark, Little Falls, Raven Rock, Wilburtha and Princeton, operated to some extent. There are said to be active quarries at Martinsville and Warrenville.

Brownstone has been quarried at the following points, some of which may still produce good stone: Patterson, three quarries south of the city; Orange, Bells' quarry; New Brunswick, Jas. Neilson's quarry; Kingston; Milford, flagstone, Clark's and McGuire's &

*References:
1. Building Stones of Minnesota, by N. H. Winchell, in Geology of Minnesota, Vol. I, 1884.
2. Illustrated circular, Minnesota Sandstone Company.

Rawling's quarries; Woodville, Burrough's flagstone quarry; Alpine; Englewood, from drift boulders; Homestead, red sandstone, poor quality; Salterville, stone for local use only; Stone House Plains; Llewellyn Park; Snake Hill; Franklin Lake, local use; Haledon; Pompton, James Ludlam's quarry; Schuyler's Basin; West Orange; Washington Valley; Pluckamin, Dow's quarry; Barking Ridge; Ten Mile Run; Rocky Hill; Brookville, two quarries. Most of the quarries named are like many of those through the brownstone region of Pennsylvania, small openings operated at intervals to supply the local demand.

Probably the largest quantity of fine brownstone comes from the Avondale or Bellville quarries, operated by the Passaic Quarry Company and the Belleville Stone Company of New Jersey .

Quarries were opened here more than 100 years ago, and have been more or less extensively worked for 35 or 40 years. At one time (1881) there were 375 men at work producing annually stone valued at $225,000.

The brownstone is 50 to 70 feet thick, including considerable intercalary brown shale and some conglomerate. It has a gentle dip of 8-10 degrees to the west, so that the bed is getting deeper as it is worked from the outcrop. They are now below the level of the river and have much pumping to do. The color varies from a gray to a dark brown, but the prevailing color is a light brown. As with most brownstones it is of poor quality near the surface, being cut up by weathering agencies into small dimensions and is partially disintegrating. In the interior the beds are heavier and more regular, yet there is much waste throughout the whole bed. The most stone occurs near the bottom of the quarry. It has a moderately fine grain, works freely, and takes a smooth finish. It makes a desirable building stone, and has an extensive use in New York and other eastern cities.

The channeling machine is used a little in the heavier layers in the bottom of the quarry, but most of the stone is loosened from the quarry by wedging or blasting, the Knox blasting system being used.

The quarries are on the west bank of the Passaic river, and near the Newark and Patterson railroad, thus having shipping facilities both by water and by rail.

The quarries at Newark were at one time among the most productive in the State, the estimated value of the product in 1881 being $120,000. The condition at the present time is not known. They are about half a mile from the Passaic river and the Erie and the Delaware, Lackawanna and Western railroads. The quarry openings are 40 to 60 feet deep, in which the good stone is said to be 20 to 30 feet thick, associated with shale, and overlain wih glacial drift 10 to 30

feet thick.* The even grain and the pleasing shade of color of this stone make it a much prized building stone.* The quarries in the city of Newark appear to have been abandoned.

The Stockton-Prallsville quarries are among the most extensive in the state. Only a small proportion of their product is used for buildings, almost the entire product being used for bridges. There are nine large openings, six of which are operated by the S. B. Twining Company, one by Wm. Ledger, one by John Ledger and one by the Pennsylvania Railroad Company. They are all close to the Belvidere division of the Pennsylvania railroad and to the feeder to the Delaware and Raritan canal. The stone, which is quite hard, varies in color from a light brown to a light gray, and very much resembles the Lumberville stone in its hardness and color, apparently from the strike of the rocks forming part of the same bed. There are several streaks of conglomerate, some of it quite coarse, with pebbles two or three inches in diameter. In one of the openings the stone is very coarse grained, containing large crystals of feldspar and quartz. Like the Lumberville stone, while it is quite hard to cut and dress, it is easily split, and can be readily made into rock faced work.

The Wilburtha (Greensburg) quarries were at one time among the most productive in the State, but at the present time they do not appear to be very active, some idle entirely, and some working on a very small scale. These quarries have produced great quantities of brownstone known in the markets as the Trenton Brownstone, the quarries being but a few miles above Trenton.†

The thickness of the stone in the Wilburtha quarries is 25 to 35 feet including some intercalary shale. Like all the stone of the Delaware valley it has a light brown color, not so light, however, as the Stockton and Lumberville stone, and about the same as the Yardley stone. It resembles the Yardley stone in its softness, being much softer than the Stockton stone. The Wilburtha quarries, like the Stockton quarries, are along the Belvidere division of the Pennsylvania railroad, and the Delaware and Raritan canal.

There are three quarries at Martinsville, New Jersey, but one of them has been abandoned, and the other only furnishes rough stone for foundations. The Bartte quarry furnishes large quantities of fine cut stone for buildings, most of it a light gray color.‡

Handsome building stone has been quarried at Little Falls, Trinity Church and Trinity Chapel, New York, and the United States Custom House and Postoffice, at Newark, attesting its beauty. There

*The data in regard to the Newark quarries is from the Annual Report State Geologist of New Jersey, for 1868 and 1881.

†Trenton brownstone now may mean stone from any of the Delaware valley quarries; besides the Wilburtha quarries, it includes the Yardley, Pennsylvania; Stockton, New Jersey, and Lumberville, Pennsylvania, quarries.

‡Annual Report State Geologist, New Jersey, 1881, p. 54.

are said to be three grades, a light brown, a light gray, and a dark brown.

Three quarries have been operated at Patterson, but are not known to be active at present. At Pleasant Valley and Washington Valley are quarries where nice brownstone has been quarried in years past.

New York.

Limiting the term brownstone to the brownstone of Triassic age, New York has little worth mentioning, there being only a few small quarries which furnish stone for local use, located along the Hudson, at Nyack and Haverstraw.

Valuable quarries of red and brownstone occur in New York in formations other than the Triassic. From the Potsdam sandstone of Lower Silurian age near Potsdam, pink and red sandstone are quarried in large quantities. The stone is hard, strong, durable, fine grained and a valuable building stone. It might almost be called a quartzite, so hard it is. Despite the fact that it is difficult to quarry and work, it is an important and valuable stone, because of its beautiful color and great strength and durability.

It is quarried extensively by the Potsdam Red Sandstone Company and the Clarkson Quarries Company. In a series of comparative tests published by Professor Smock,* the Potsdam stone stood the tests better than any other stone on the list.

The Potsdam stone is quarried at Port Henry and other points in New York, but as it is mostly of a gray color† it does not come in the province of this report.

The most important brown or red stone in the State is that from the Medina red formation in the western part of the State. The principal quarries are located along the New York Central railroad west of Rochester, at Medina, Albion, Lockport, Hindsburg, Hulberton, Holley and Brockport. Merrill says‡ the leading varieties are three, known as the Medina red stone, the white and gray Medina, and the variegated red and gray. The quarries in this district are worked on an extensive scale, and their equipment is adequate to a large annual production.

The aggregate output is larger and more valuable in dimension stone for dressing than any other quarry district in the state. The stone has gained a well deserved reputation for its value as a beautiful and durable building material, and its more general employment, both in construction and in paving is much to be desired.

This stone has been used extensively in Buffalo, both in paving and in construction, a great many churches and fine residences being

*Bulletin New York State Museum, Volume II, No. 10.
†Bulletin New York State Museum, Volume III, No. 15, pp. 391-4.
‡Bulletin No. 16, Volume III, New York State Museum, pp. 386.

built of it. It is fully as brown as much of the Triassic brownstone, but hardly as uniform in color.

The Medina stone has also been quarried at Oswego, Oswego Falls and Granby, Oswego county, that at the first two localities being of an inferior quality. The quarry at Granby on the Delaware, Lackawanna and Western railroad operated by the Granby Brownstone Company, produces a fine grained purplish red stone used for building in the neighboring towns.*

North Carolina.

The Triassic brownstone of the same age and similar in appearance to that in the more northern states occurs in commercial quantities in several places in North Carolina. It has been quarried at Wadesborough, Anson county; Gulf and Egypt, Chatham county, and Sanford, Moore county. Letters of inquiry to the different companies said to be in operation recently elicited replies from but one, the Aldrich Stone Company at Sanford, who opened a quarry in 1893, which has been in active operation since that time. This quarry is located on the Seaboard Air Line and Cape Fear and Yadkin Valley railroads, and they ship stone over both roads to the southern and eastern cities.

The company reports a thickness of 12 feet of stone that have been worked, with a second layer not yet opened. A sample of the stone furnished by the company shows a strong stone of light, pleasing color, intermediate in shade between the bright red of the English stone, and the dark brown of the New England stone. See tables pages 13 and 30 for tests.

At Wadesborough it is said† the stone lies in beds from two to ten feet in thickness, which are inclined to an angle of 25 degrees. It has a fine, even grain, dark brown and reddish colors.

Ohio.

Brownstone occurs in several places in Ohio, as shown by the samples in Orton Hall, at the Ohio State University, at Columbus, but the only one known in the general market is the Killbuck stone. The quarry is located on a hill about three quarters of a mile above the Killbuck station, on a branch of the Akron, Cleveland and Ohio

*References:

1. Building Stone in New York, by J. C. Smock. Bulletin New York State Museum, Volume II, No. 10.
2. Building Stones in the State of New York, by J. C. Smock. Bulletin New York State Museum, No. 3, March, 1888.
3. Report on Building Stones by James Hall, in Thirty-ninth Annual Report New York State Museum, 1886.
4. Mineral Resources of New York State, by F. J. H. Merrill. Bulletin New York State Museum, Volume III, No. 15, 1895.
5. Stones for Building and Decoration, by G. P. Merrill, New York, 1891.
6. Potsdam Red Sandstone, illustrated; Stone, Volume VI, No. 4, pp. 289-301, March 1893.

†Merrill—Stones for Building and Decoration, p. 274.

railway, which distance the stone is hauled by wagon. The quarry has been operated since 1886 by the Killbuck Sandstone Company, and the stone has been shipped to many towns in Ohio, to Pittsburg, Pennsylvania, and in small quantities to other states.

The stone is quite variegated in color, in fact as far as could be observed, there is no stone of uniform color in the quarry, nor in the buildings in which it has been used. The color varies from dark gray to dark brown. It is coarse grained, even fine conglomerate in places. The thickness of the quarry stone varies from eight to thirty feet in different parts of the quarry; the overlying material consisting of shale and sandstone is 25 to 30 feet thick in the middle of the quarry.

The stone is apparently a strong, durable one, but can never be classed with the finer building stones, because of its variegated color. The drilling is done by hand and the stone wedged or blasted loose.

Another quarry is being opened (1896) about a mile north of the Killbuck station, which is said to have a thickness of 45 feet of stone of more uniform color than the older quarry.

South Dakota.

At Sioux Falls, South Dakota, there is a red quartzite that has been used to some extent for building stone. While some of it has been used in Chicago, and a little in the eastern cities, the output is not large, and within the last year or two the quarries have either been idle or running on a small scale. Letters to the different companies elicited no response.

It resembles the Potsdam stone of Potsdam, New York, in some respects, but seems to be even more quartzitic. It resists a pressure of 25,000 pounds to the square inch, and will take a brilliant polish. Like the Potsdam stone it varies from pink to red. It is adapted to either exterior work or interior decoration, where the expense of working it will justify its use. While one of the most durable and handsome stones, it is very difficult to work. It is well adapted to city work, as it is not easily abraded nor easily discolored. Professor Beyer, of Ames, Iowa, who has written a thesis on this stone,* says it has been quarried at Sioux Falls, Dell Rapids and Garretson, South Dakota, Granite in Iowa, and Pipestone and Lucerne in Minnesota, but in all these places, he says, little has been done in the last three or four years.

Virginia.

The Triassic brownstone occurs in several small areas in the state of Virginia, but as far as could be ascertained the only place it has been quarried to any extent is in the vicinity of Manassas, and so far

*The Sioux Quartzite and certain associated rocks, by Samuel W. Beyer, in Iowa Geological Survey, Volume VI, 1896.

as is known, there is only one quarry in operation there. That belongs to J. R. Tillett, who has owned the quarry about seven years, but it has been in operation about thirty years. It is located on the Richmond and Danville railroad, owning its own side track. The stone is described by Merrill as occurring in horizontal layers* near the top of a low hill. The layers vary in thickness from one to six feet, and have been quarried to a depth of about 20 feet.

Wisconsin.

Brownstone occurs in Wisconsin on the south shore of Lake Superior, not far west of the Michigan border. The stone is said to resemble the Portage Entry stone, and belongs to the same age. There are quarries on Bass Island and on Wilson Island, and at Houghton and Washburn, the two latter having boat and railway transportation, while the others ship by boat.

The Prentice Brownstone Company has extensive quarries at Houghton, Michigan. Analysis and tests of their stone are shown in the tables on pages 13 and 30. No samples or description of the stone is at hand, nor could replies be secured from any of the other companies.

Professor Conover states† regarding Lake Superior stone in Wisconsin, that it is composed of siliceous grains, medium to coarse, in an iron or clay cement, and varying from yellow to deep brown in color. It furnishes a handsome building stone, the chief difficulty being the numerous clay pockets that pit the surface of the stone. There are numerous exposures on the islands and along the lake shore where the stone can be loaded directly from the quarry on the boat. The large quarry at Bass Island, not then (1880) in operation, has a thickness of 26 feet of good brownstone of much the same grade as the Marquette stone, overlain by a heavy clay stripping.

English and Scotch Red Stone.

‡Red sandstones are quarried extensively in both England and Scotland, but a comparatively small quantity is imported into this country.‖ The best stone that is imported into this country is said to come from the Annan District, Dumfries, Scotland, and Cumberland county, England. The Gatelawbridge Scotch redstone is also used in New York. The Murray quarry of Annan is said to be the largest of all and furnishes more redstone to this country than any other quarry.

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*Stones for Building and Decoration, p. 284.

†Tenth Census, Volume X, p. 230.

‡The writer is indebted to George W. White, of New York, and Frank Williamson and William Gray & Sons, of Philadelphia, for information concerning the foreign stones in this country.

‖A description of the principal varieties may be found in Hull's Building and Ornamental Stones, and a briefer description in Merrill's Stones for Buildings and Decorations.

The bright red color, and the ease with which it is worked, are points in favor of most of the foreign stone, as none of the eastern stones of this country have as bright a color as the foreign stone, but one variety of the Michigan stone, from Portage Entry, that is now coming into the eastern markets very closely resembles the foreign stone in color, and the red stone from East Longmeadow is said to resemble it somewhat. The red stone from these two localities is said to be largely replacing the English and Scotch redstone in the eastern markets.

Some of the buildings in Philadelphia in which the foreign red stone is used are the Bourse, Fidelity and Trust Building, Bank of the Republic, Wood, Brown & Company building, and John C. Bullitt's residence. The stone is said to withstand the climate better in this country than in England.

The tenth census report gives red and brown sandstone used in New York city from the following localities: Corsehill (near Annan) about 60 miles west of Glasgow, dark red to bright pink, close grained, weathers well, works easily; Ballochmile, Forfarshire, Scotland, darker than the Corsehill stone; Gatelawbridge, 30 miles from Ballochmile; and Frankfort-on-the-Main, Germany.

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